OBSERVATIONS ON SCHISTOSOMIASIS AND PARAMPHISTOMIASIS IN SHEEP AND NOTES ON THE MORPHOLOGY OF HELMINTHS FROM MAMMALS AND BIRDS IN SOUTH AFRICA.

By

Philippus Lodewicus le Roux, B.Sc., M.R.C.V.S.,

Veterinary Research Officer,
Department of Veterinary Services,
Mazabuka, N. Rhodesia.

<u>CONTENTS.</u>

Article No.6.

On a Hookworm (*Agriostomum gorgonis*, sp. nov.) from the Blue Wildebeest (*Gorgon taurinus*) in the Transvaal.

Article No.7.

A Spirurid (*Streptopharagus geosciuri*, sp. nov.) from the Stomach of the Cape Ground Squirrel (*Geoscuirus capensis*).

Article No.8.

The Generic Position of *Oxyuris polyoon* von Linstow, 1909, in the Suf-family *Oxyurinae*, Hall, 1916.

Article No.9.

An Acuaria (*Acuaria martinagliai* sp. nov.) from a South African Weaver (*Hyphantornis* sp.).

Article No.10.

A New Nematode (*Rictularia aethechini*, sp. nov.), a Physaloptera and an Acanthocephala from the Hedgehog (*Aethechinus frontalis*).

Article No.11.

On Two New Helminths from the Abomasum of the Bushbuck in Zululand, Natal.

Article No.13.

On *Longistrongylus meyeri* gen. and sp. nov., a Trichostrongyle parasitizing the Red Hartebeest (*Bubalis caama*).

Article No.14.

On *Trichostrongylus pietersi*, sp. n., a Parasite of Sheep and Goats.

Article No.16.

On *Tenuostrongylus cynictis* gen. et sp.n., a Trichostrongylid parasitizing the Yellow Mungoose (*Cynictis penicullata*).

Article No. 1.

15th Annual Report of the Director of Veterinary Services, Union of South Africa. October, 1929.

Remarks on the Habits and the Pathogenesis of *Schistosoma mattheei*, together with Notes on the Pathological Lesions observed in Infested Sheep.

By P. L. LE ROUX, B.Sc (Edin.), M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

INTRODUCTION.

THE prevalence of Schistosomiasis as an ovine malady of Merinos in the Cape Province was first recognized in 1926 when Mr. Edgar, the Government Veterinary Officer then stationed at Port Elizabeth, was questioned by a young farmer, Mr. S. W. Matthee (L.'s son), about peculiar white objects seen in the mesenteric veins of his dying sheep.

Before describing the habits of *S. mattheei* Veglia and Le Roux, 1929, in the definitive host or recording the pathological lesions provoked by this species, it seems desirable to review briefly the lesions attributed to certain schistosomes parasitizing cattle and sheep.

Although the pathological lesions associated with the three common human schistosomes have received the attention of a host of investigators and have been dealt with in innumerable publications, the pathology of the analogous disease in domestic stock has been sorely neglected.

It is surprising that, although schistosomiasis of domestic animals has been known since 1876 and is widespread, pathologists have little availed themselves of the opportunity of studying the analogous disease in domestic stock. A comparative study would undoubtedly have resulted in the elucidation of various points, associated with human schistosomiasis, which have puzzled man for years. Experimentation with domestic stock would have facilitated and permitted experiments to which man cannot be submitted.

Fairley (1920), utilizing monkeys for investigating some of the more puzzling points, made interesting observations. His experiments have added to our knowledge of the lesions provoked. The same author four years later used goats to test the efficacy of tartar emetic and emetine hydrochloride against *S. spindalis*.

The smaller laboratory animals, and even the domestic fowl, have within recent years been utilized in determining the life-cycles of the common human schistosomes. Although the cat and the dog are very suitable experimental animals for the study of the pathology and habits of *S. japonicum*, I have been unable to trace much literature in this connection.

OBSERVATIONS ON THE HABITS OF "S. MATTHEEI."

As some of the observations on the behaviour of *S. mattheei* in the definitive host are at variance with those recorded for other schistosomes, I propose dealing with my findings in detail.

THE DISTRIBUTION OF THE PARASITE IN THE SHEEP.

The pathological lesions produced by schistosome infestation have been shown by various investigators to be closely related to the veins invaded.

The habitat of *S. mattheei* was found to be influenced by certain factors and it is accordingly considered advisable to discuss the distribution of the parasite in the definitive host as observed in sheep killed for autopsy, in sheep killed after treatment, and in sheep dead from natural causes.

(a) *The Distribution of the Parasite in Naturally Infected Sheep killed for Autopsy.*

In the majority of sheep killed for autopsy the adult schistosomes were most abundant in the smaller veins draining the small intestine and the caecum. They were less frequent in the larger radicles of the portal vein, the portal vein itself, and its hepatic ramifications.

In animals not heavily infected, schistosomes were rather infrequent in the hepatic branches of the portal vein. This predilection for the small intestine and the caecum accounts for the heavy deposits of ova in the submucosa and the mucosa of these parts.

The invasion of the veins draining the *rumen*, *reticulum*, *omasum*, *abomasum*, *pancreas*, *colon*, *rectum*, and *mesenteric lymphatic glands* was as a rule very light. Nevertheless, a careful search revealed the presence of specimens. The *splenic vein* was very seldom invaded. In none of these cases were schistosomes observed in the veins draining the urino-genital organs. A careful search of the posterior vena cava and its pelvic branches, the cavities of the heart, and the pulmonary arteries and veins failed to reveal any parasites.

(b) *The Distribution of the Parasites in Animals which had received Intravenous Injections of Tartar Emetic, Emetine Hydrochloride and Sb.* 212.

That the administration of the drugs mentioned caused the affected parasites to migrate from their normal habitations was evident from the finding of abnormally small schistosomes in great numbers in the portal vein and its hepatic branches and in fair numbers in the right heart, the posterior vena cava, and the pulmonary arteries and their sub-divisions.

No parasites were recovered from the left heart, the coronary arteries, the pulmonary veins, the aorta and its branches, nor in the veins of the urino-genital tract.

(c) *The Distribution of the Parasites in Animals dead from Intercurrent Diseases.*

The observations were made on animals which had died from heartwater on the infected farm, and on animals which had died shortly after arrival at this Institute. The infected animals stood the 820 miles railway journey lasting four to five days very badly.

The distribution of the schistosomes in animals which had succumbed after a prolonged period of *decubitus* showed a variation from the two groups described above. In these cases there was a decrease of parasites in the venules and smaller veins draining the small intestine and caecum, but a marked increase of parasites in the larger tributaries of the portal vein. The blood-clots from the portal vein and its hepatic branches contained schistosomes in great abundance. In most of these animals schistosomes were present in fair numbers in the right ventricle and auricle and the pulmonary arteries and their ramifications. None were present in the left heart, pulmonary veins, or the veins of the urino-genital organs.

CONCLUSION AND DISCUSSION.

From the observations on these three groups it is evident that normally the adult *S. mattheei* inhabits the tributaries of the portal vein, but that adverse conditions cause the parasite to migrate into other localities.

Probably in the case of the dying animal the toxins diffusing into the bloodstream from the decomposing, stagnant alimentary contents, cause the parasites to forsake their normal habitat in search of a more congenial one elsewhere. With the administration of drugs lethal to schistosomes the same results were obtained.

Although it has been assumed (Fairley, 1920) that schistosomes can reach the pulmonary arteries via the haemorrhoidal plexus, this has not to my knowledge been confirmed.

Lampe (1927) is of the opinion that, in cases of heavy infestations, some cercariae may remain in the pulmonary arteries and complete their development there. He further states: "My opinion, based upon pathological-anatomical alterations in the lungs of bilharzia patients, is that full-grown parasites in the lungs need not be rare." He records a case where he squeezed a few full-grown *S. mansoni* from the pulmonary vessels. He unfortunately does not specify whether these were from the arteries or the veins nor does he specify whether the observations were made on a human who had succumbed prior or subsequent to the administration of a drug lethal to schistosomes.

Turner (1909) records adult schistosomes (*S. haematobium*) from the pulmonary vessels of natives who died on the gold mines in Johannesburg. Houghton (1923) records *S. japonicum* from the pulmonary arteries of man.

The presence of adult schistosomes in the lungs of man and animals has been recorded by only a very few investigators.

OBSERVATIONS ON THE MIGRATION OF OVA.

Fairley (1920) discusses in detail the penetration of the wall of the venule and the passage of the ova of *S. mansoni* and *S. haematobium* into the perivenous tissue. According to him, the spines of the deposited ova engage the vessel wall and pierce it. The force of the venous bloodstream drives the ova through the wall of the venule. I fail to see how the force of the venous bloodstream alone can accomplish this. Should the rupture of the venules and the migration of the ova through the tissues into the lumen of the gut not be attributed partly to the peristalsis of the intestines? During slight constipation, ova and bloodstained mucus, containing ova in clumps, were more abundant than with softer faeces. This seems to indicate that the migration and liberation of ova deposited in the latter part of the large intestine is greatly influenced by the passage of rather firm faeces along the alimentary tract.

Fairley (1920) describes the passage of the ova from the perivenous tissue into the lumen of the gut as follows: " The spines," after piercing the wall of the venules, " take no part in the process of extrusion of the ova through the tissues to the exterior, which is dependent on the inflammatory softening and cellular accumulation in its vicinity."

This statement cannot be accepted. The pathological changes observed in sheep and guinea-pigs disprove it.

Dew (1923) expresses views similar to those of Fairley. It seems unlikely that the ova deposited in the intestine of man and monkeys should behave differently from those in sheep and guinea-pigs.

In Byam and Archibald (1923) we read that the ova progress through the tissues by elaborating a toxin and that the ova consequently become surrounded by eosinophiles, polymorphonuclears, and small mononuclears. The progress is therefore attributed to a process of ulceration.

According to Hutchison (1928), the escape of the ova from the mucosa is accomplished by a process of ulceration, described as follows: " An intense inflammatory reaction occurs with the accumulation of many leucocytes, lymphocytes, and endothelial cells. Among the leucocytes is a large number of eosinophiles. Irritation of the mucosa and the loss of its normal resistance to bacterial invasion result in actual abscess formation. The abscesses are as a rule very superficial. As they rupture into the lumen of the intestine or bladder, they discharge ova together with their contents. Granulations spring up at once in the ulcerated areas and may become excessive. As they grow they continue to carry ova up through the mucosa to the surface. From the fact that adult parasites are commonly found in the loose areolar tissue under such areas of ulceration and granulation tissues, and from the large number of ova in such a place, it seems likely that the gravid female is attracted to areas where the processes of tissue repair are active."

It seems most unfortunate that such conclusions should have been arrived at from the study of material collected from heavily infested humans where death had probably intervened only after a protracted period of *decubitus*. It seems most unlikely that the material examined was obtained from subjects which had succumbed from pure infections of schistosomes. It is a well-recognized fact that the type of Egyptian on which post-mortems are allowed is of the working class. He is not uncommonly a subject of malnutrition and not infrequently heavily infested with a host of endo-parasites, protozoal as well as metazoal.

My experience with sheep is that only those free of other diseases affecting the alimentary tract, and killed for autopsy, are suitable subjects in which to study the migration of the ova through the tissues into the lumen of the gut.

THE MIGRATION OF THE SCHISTOSOMES IN THE BLOOD-VESSELS.

Fairley (1920), recording his observations on *S. haematobium* and *S. mansoni*, states that progression within the veins is by peristaltic-like movements of the body and by the action of the ventral sucker.

In the case of *S. mattheei* progression is by a rather interesting cycle of somatic movements, depending on the calibre of the invaded blood-vessels.

In the larger veins, with the wall not contracting on the body of the parasite, progression is essentially, if not wholly, by prolongation and contraction of the portion of the body situated anterior to the ventral sucker, aided by the two suckers acting as organs of fixation. The parasite proceeds as follows: It anchors itself to the wall of the vein by means of its ventral sucker armed with spines; the portion anterior to the ventral sucker is protruded, and whilst fully extended, the armed convex ventral surface of the projecting dorsal portion of the anterior sucker is firmly affixed to the vessel wall; the ventral sucker is released and the protruded portion contracts. Considerable ground is thus covered with each cycle of movements completed.

Progression in the smaller veins, distended by the parasite, is somewhat modified. The posterior portion of the body is now also actively utilized. Since the anterior portion can no longer drag along the rest of the body, we find that the massive posterior portion forces itself along by a series of somatic prolongations and contractions. The well-developed layers of muscles are now brought into play. The cycle of events here is somewhat as follows: A portion contracts, forming a circular swelling distending the enveloping vein still further and fixes the parasite, while the immediately anterior portion is protruded along the vessel: a swelling as described above now forms at the end of the extended portion. This enables the posterior portion of the parasite to be drawn forward.

Several of these circular swellings may be observed to appear simultaneously along the body. The retreat of the parasite from an invaded and distended venule is undoubtedly achieved in like manner, but in the reverse direction.

The cuticular tubercles, armed with spines, on the external (dorsal) surface of the male are undoubtedly adaptations for facilitating and accelerating progress. That their presence is not absolutely essential for migration is proved by their absence in *S. japonicum*, a species parasitizing man, his domestic stock, and other mammals in the Far East.

The presence of a *dorsal groove*, not hitherto described for male schistosomes, may now be recorded. This groove, extending from the shoulders posteriorly, was not only evident in transverse sections of the parasite in tissues, but also in the fresh and in the preserved specimens. Anteriorly it is deep, but becomes more shallow posteriorly. That one of the human schistosomes possesses a similar groove is evident from Hutchison's (1928) figure 3, plate 2. It is quite probably an adaptation to prevent total arrest of the venous flow in the invaded veins. Complete stagnation of blood in a vein would undoubtedly affect the parasite adversely.

Fairley (1920) and Dew (1923) state that the females of *S. haematobium* and *S. mansoni* leave the males, when the time for oviposition arrives, to invade the smaller venules of the selected organs. This desertion of males was not manifested by the females of *S. mattheei*. Males still partially embracing the females were often encountered in the submucosa of the invaded alimentary tract. I have, hitherto, not yet encountered females, unaccompanied by males, in the wall of the digestive tube.

It seems quite unnecessary that females, in search of venules in which to oviposit, should abandon the males. The arrangement of the venules within the wall of the gut is such that numerous venules, suitable for oviposition, are within easy reach. In the many cases examined the female does not necessarily continue in the vein selected by the male, but was almost without exception found with her anterior half invading a small collateral tributary of the vein holding the male.

The progression of the female within the venules is, as in the males, accomplished by a series of somatic movements, in which the anterior and ventral suckers and the intervening portion of the body play a not insignificant rôle. The mode of retrogression from the invaded venule appears to be accomplished by a contraction of the body, commencing at its attachment to the male, and by traction applied by the male. It would, therefore, appear essential that a portion of the female be permanently clasped by the male.

Most of the pairs encountered in the large veins appeared with a short length of the caudal extremity of the female trailing behind and with the cephalic portion just protruding from the anterior limit of the *gynaecophorus groove*. In others the female is wholly imprisoned in this groove and eggs are occasionally deposited here.

Whether the spines in the *gynaecophorus groove* allow the male the recovery, actively or passively, of the ovipositing female is not definitely settled. That muscles control their direction is evident, but whether they are actively or passively utilized to allow the partial escape and the total recovery of the female is still to be solved.

It seems possible that the female, uterus laden with eggs (seventy to ninety is a common number), migrates into a venule. As she is withdrawn by the male, the venule, closely contracting on her body, forces the eggs out. The presence of forty or more eggs lying in a row and partly overlapping each other seems to favour this mode of oviposition more than that outlined by Fairley (1920). The uterus having been emptied of most of its eggs, the female withdraws or is withdrawn into the *gynaecophorus groove* of the male to feed, and produce more eggs. The fact that parasites were never encountered singly, in sheep destroyed for autopsy, seems to indicate that schistosomes are normally monogamous. That separation, by accident, must occasionally occur is to be expected.

In animals which had succumbed after prolonged *decubitus* and in animals subjected prior to destruction to drug-treatment, single males and females were occasionally observed in the larger tributaries and hepatic branches of the portal vein and in the pulmonary arteries.

In none of the naturally infected sheep were males more frequent than females, as recorded for other schistosomes [Montgomery (1906) and Fairley (1920)]. These authors based their finding on parasites collected solely from the portal vein and its hepatic branches.

The females, owing to their dark colour, are not so easily detected in the clotted blood as are the stouter and lighter coloured males. Montgomery examined animals which had either died of *Surra*, in the case of equines, or of *Gillar*, in the case of sheep. In the case of the monkeys and the goats artificially infected by Fairley, the predominance of males may be attributed to: (i) that more male than female producing cercariae [Cort (1921), Faust (1927), and Severinghans (1928)] were administered; or (ii) that prior to death, or as the result of treatment with drugs, the males became separated from the females, which, for reasons given above, were not so readily detected.

THE PATHOLOGICAL LESIONS RECORDED FOR SOME OF THE KNOWN ANIMAL SCHISTOSOMES.

In 1876 Sonsino recovered a schistosome from the portal vein of a bull at Zagazig in Egypt. On account of the peculiar shape of the ova, he regarded it as a new species and named it *Bilharzia bovis*. On recovering it the following year from the portal veins of sheep, he changed the name to *Bilharzia crassa*. No matter how unsuitable, the former name has preference.

Having been unsuccessful in obtaining Sonsino's original communication describing the lesions observed in infested sheep and cattle, I shall quote his findings as translated by Fleming (1892) from Neumann (1888). These read:

> "In an ox, the blood of which furnished thirty of these parasites, Sonsino observed very pronounced intestinal catarrh, with thickening, exudation, and ecchymoses in the walls of that tube. The vesical mucous membrane was ecchymosed and covered with papilliform elevations, which were yellow at the point and about the size of a pin's head. The vessels contained the ova of Bilharzia."

In the same paragraph the author continues: "It is possible that the haematuria which so frequently affects cattle in East Africa and the Cape of Good Hope is due to this parasite." It is not quite clear whether this last quotation should be attributed to Sonsino or Neumann himself.

Neumann's (1888) statement:

> "Le *B. crassa* détermine chez les animaux des désordres analogues à ceux qu'engendre chez l'homme le *B. haematobia* "

has undoubtedly influenced many subsequent authors of textbooks on Veterinary Parasitology and Pathology.

Stiles' (1898) statement:

> "The worm is said to bring about in cattle and sheep the same lesions of the bladder, intestine, etc., which *S. haematobium* causes in man"

has apparently influenced American veterinary literature. According to Stiles (1898), two transport bullocks suspected of being affected with rinderpest were destroyed in Calcutta. From the anus of one, Bomford removed papillomatous growths harbouring ova resembling those of *S. haematobium*. In the mucosa and submucosa of the caecum from the other he observed numerous ova.

Kaupp (1918), discussing "*Schistosomum bovis*," writes:—

> "The flukes are found principally inhabiting the veins of the abdomen, more especially the venous plexuses of the bladder and rectum. They may cause nephritis, cystitis, and as a result bloody urine or faeces. The adjacent lymph glands become hypertrophied. The condition may terminate in death."

Underhill (1920), in a textbook on Veterinary Parasitology, considers under the heading "Bilharziosis" only *Schistosoma bovis* and mentions haematuria, painful micturition, bloodstained faeces, and "a condition somewhat resembling piles" as the chief symptoms of schistosomiasis in cattle and sheep. According to this author, most animals being only lightly infected, show a slight chronic cystitis, whereas heavily infected beasts may succumb from rupture of the urinary bladder or from uraemia, sequelae to acute nephritis.

Piller (in Hoare, 1915), in his chapter on "Trematodes of the Ox," writes:—

> "Schistosomiasis or bilharziosis is manifested chiefly by symptoms appertaining to the bladder. These are due to the eggs, and not the adult parasites. Haematuria is usually the first alteration in health; then there is pain in the loins and urino-genital tract."

Henschen (see Joest, 1923) writes:—

> "Von Pathogen Trematoden der Blase kommt bei den Haustieren eigentlich nur eine Art, *Schistosomum crassum* vor. Er wurde hauptsächlich in den Mittel-meerländern gefunden, besonders beim Rind, weniger oft beim Pferd und Schaf. Der erwachsene Parasit lebt im Pfortadersystem und gelangt von dort in die Venen des Darms und der Blase. Aus den Gefässen der Blasenwand kann er ins Blasenlumen eindringen, wonach er entweder hier liegen bleibt oder mit dem Harn gleich ausgespült wird. In der Harnblase entwickeln sich geschwürige Prozesse (Marotel), die selbt zur Perforation führen können (Piot-Bey). Oft nimmt der Prozess einen mehr produktiven Charakter an, wobei kleine warzenförmige Neubildungen entstehen."

Woolridge (1923), under "Bilharziosis," writes:—

> "The immature stages of various species of Bilharzia worm inhabit the portal veins of the liver. When numerous they may give rise to enlargement and cirrhosis of the liver with the development of white plaques of fibrous connective tissue surrounding the portal vessels. The lesions result chiefly from the irritation by the eggs laid by the parasite, and partly to toxins they elaborate. Clinically the principal symptoms are those of dysentery, due to a similar deposition of eggs in the finer branches of the portal veins in the walls of the intestine, especially the rectum."

The following passages from Ceradini's review of Bertolini's (1908) article are well worth quoting:—

> "niemals aber konnte bei den sardinischen Rindern die Bilharziose der Blase wahrgenommen werden."
>
> "Die Veränderungen des Dunnsdarms kommen bei der Bilharziose der sardinischen Rinder durch katarrhalische Enteritis und Knotchenbildung in der Submucosa zum Ausdruck. Die Veränderungen des Mastdarms sind viel weniger stark ausgesprochen und' betehen hauptsächlich in kleinen punktförmigen Blutungen der Schleimhaut."

"Die Knotchenbildungen in der Submucosa des Dünndarms werden durch *Bilharziaeier* und junge Exemplare des incystierten Wurms hervorgerufen, haben aber durchaus nichts zu tun mit den hyperplastischen Formen und den polypenförmigen adenomatösen Vegetationen, die *Bilharzia* Mastdarmenzundung beim Menschen kennzeichnen."

"Der erwachsene Parasit wählt sich mit Vorliebe das Pfortadersystem zum Sitze aus und ganz besondere dessen hepatische abzweigungen, sowie die Venen des Dünndarms."

In Chopra and Chandler (1928) we read:—

"Schistosomes of several species, of which the commonest is *S. bovis*, live in the mesenteric blood-vessels; as in the case of human schistosome infections, severe mechanical injury is caused by the eggs to the walls of the bladder and rectum, but much is still to be learned as to the degree to which cattle suffer from these infections. The life-cycles of these worms is similar to that of the schistosomes of man. Schistosomes infect sheep and goats, and in experimental animals have been shown to be injurious."

Marotel (1927) reports on the pathogenesis of *Schistosomum bomfordi* as follaws:—

"Schistosomose bovine, se traduisant par une entérite, avec *ecchymoses* punctiformes, *ulcérations* hémorragiques, *végétations* polypeuse; outre ces altérations dues aux oeufs, on observe encore des *nodules* sous-muqueux développés autour des femelles contenues dans les veinules."

v. Ostertag (1923) reports on Schistosomiasis of cattle as follows:

"Manche der mit Schistosomiasis behafteten Rinder leiden an Haematurie; bei der Schlachtung findet man die Parasiten (dauernd das Weibchen vom Mannchen umschlungen) in den Hinterleibsvenen, ferner chronische Enteritis mit nekrotischen Herden in Darme, in denen meistens die Eier des Schistosomum finden, und Knotchen (mit den Larven des Schistosomum) im Dunndarm."

In the following words Khalil (1924) refers to the pathogenesis of *Schistosoma bovis*:—

"The disease affects cattle and sheep, causing lesions similar to those in human bilharziosis. In a fair number of the cases reported, although the adult parasites were found, no lesions or only slight partly congestion of the lower part of the large intestine was found."

"Cirrhosis of the liver is caused by *S. bovis* infection, just as in human infection especially with *S. mansoni*; but cirrhosis in cattle is common and is caused by a multitude of parasites, a common cause in Egypt being *Fasciola gigantica*."

He further comments on the suspicions of various observers that *S. bovis* may be the cause of haematuria in cattle in East Africa and the Cape. He is, however, inclined to ascribe this haemoglobinuria to *Piroplasmosis*. He does not mention the existence of *Piroplasmosis* in Egypt.

He records the Cape as an endemic area for *S. bovis*, but unfortunately omits to quote his authority. In an extensive hunt for references, I have failed to trace any communication recording the recovery of schistosomes from cattle and sheep in the Union of South Africa. Mönnig (1928) lists *S. bovis* as having been found in the heart and blood-vessels of cattle, especially in Natal. He does not quote his authority. I still believe that this article contains the first record of schistosome ova having been recovered from the faeces of cattle in the Union of South Africa. The ova were identical with those from the infected sheep on the same farm.

Faust's (1926) statement: "In fact, the 'cow' hypothecated by Dr. Cawston may not be necessarily involved in the *Schistosoma bovis* life-cycle in Natal; man may possibly serve in this capacity," is based on a statement from Cawston (1920) that he has not yet traced the cow, the usual host of *Schistosoma bovis*.

Montgomery (1906) records the finding of schostosomes in the portal veins of two sheep from Bareilly near Lahore. No macroscopic pathological lesions were, however, seen nor were ova found. He admits, though, that a careful examination was made only of the rectum and urinary system. These schistosomes he evidently regarded as *S. bovis*. He next mentions that Baldrey had recovered from sheep schistosome ova of the human type (presumably, ova shaped like those of *S. haematobium*) and closely resembling those of *S. indicum*.

Montgomery finally recovered from the portal system of two other sheep adult schistosomes indistinguishable from *S. indicum*. He observes that there were no lesions beyond "small areas of discrete punctiform haemorrhages present throughout the length of the small and large intestines."

Baldrey (1906), in his discussion of *Gillar*, records having found eleven of the fifteen Gillar affected sheep infested with schistosomes resembling those recovered by Montgomery from the sheep, horse, and donkey.

According to Baldrey, the lesions attributable to this parasite were only evident in the small and large intestines, noticeably so in the duodenum. He records a muco-enteritis, with the mucosa necrotic and probably shedding off in places. Here and in the mucosa of the rectum schistosome ova could be demonstrated. The liver, spleen, kidneys, pancreas, lungs, and heart were not affected. He described changes, observed in the mesenteric and omental fat, which indicate fat necrosis.

Gillar is undoubtedly a malady provoked by a heavy panverminosis in association with a decrease in the amount of nutritious foods available in the natural pastures during the lean seasons.

The immature amphistome, mentioned by Baldrey in his article, is in the Union of South Africa occasionally responsible for heavy mortality amongst sheep and cattle, and was probably the cause of the lesions attributed by him to *S. indicum*.

According to Lee (1927), *S. indicum* would appear to be a comparatively benign haematozoal parasite of camels in India.

Hall (1923 ?) states that *Schistosoma bovis* inhabits the veins of both the rectum and the bladder and that the eggs may therefore be passed in the urine and in the faeces.

Fairley and Mackie (1925), dealing with the pathology of *Schistosomum spindalis* in goats, state that the lesions are most closely related to those of *S. mansoni* and *S. japonicum*, which it resembles in habitat. According to them, the verminous ante-mortem thrombosis in the portal or mesenteric veins and its branches and the hepatic lesions, varying from the early bilharzial pseudo-tubercles to a "pipe-stem" periportal cirrhosis, are as common as with *S. japonicum* in man. They further observe that the spleen is seldom affected and that bilharzial papillomatosis was not present owing to the non-irritating character of the ova. The absence of any inflammatory reaction around the deposited eggs of *S. japonicum* is likewise attributed to the lack of an irritant. It seems most remarkable to assume that the ova of different schistosomes should progress through the tissue by different means and that some species should oviposit ova possessed of an irritant not present in those from other species.

THE PATHOLOGICAL LESIONS OBSERVED IN THE INFESTED SHEEP.

Apart from the presence of the parasites in the mesenteric veins, macroscopic lesions were evident in the lungs, the liver, the walls of the small and large intestines, the periportal lymphatic glands, and in the pancreas.

On opening the thoracic and abdominal cavities, the macroscopic lesions manifested varied with the age and the degree of infection and with the condition of the animal.

On exposing the abdominal contents, the first lesion to strike the eye was the presence or absence of fat in the greater omentum and mesentery. In a large percentage of cases there was an average amount of fat present. This fat invariably showed multiple fat necrosis. The absence of fat was associated with a slight hydropericardium and hydrothorax.

In the mesenteric blood-vessels the schistosomes could be demonstrated by holding a loop of gut up against the light with the mesentery still attached to the abdominal wall. In animals killed for autopsy the migration of the parasites within the veins was studied in the mesentery thus suspended.

For enumerating the number of parasites present it was absolutely essential to ligature the portal vein close to the liver and remove the intestines by severing the mesentery along its dorsal attachment. The blood from the liver and the portal vein was run into a shallow flat-bottomed circular glass dish, and the parasites collected.

When the usual post-mortem routine practised at this Institute was followed and the mesentery severed along its alimentary attachment, many parasites were lost and damaged; the collection was rendered much more tedious and difficult, and a true estimation of the number of worms present was impossible.

THE SMALL INTESTINE.

The small intestine showed fine grey specks scattered diffusely throughout its wall. The microscopic examination of a small portion of the wall flattened between glass slides showed that the pigmentation was due to the presence of numerous schistosome ova deposited in clumps or singly. A high percentage of these ova was calcified. Parasites were present in the submucosal and subperitoneal veins. Small haemorrhages in the mucosa propria were often numerous.

The caecum appeared with wall thickened. On holding the organ, incised along its mesenteric attachment, up against the light, certain areas, chiefly localized along the greater curvature, did not transmit light. (Figs. 13 and 14.) At these spots the wall was much thickened, the mucosa was sandy-coloured and emitted a grating sound when cut with a sharp broad-bladed post-mortem knife, showing that calcareous material was present. The cut surfaces showed the submucosa much thickened, pigmented, and fibrosed. Running the finger tips across these areas felt like passing them over fine sandpaper.

The colon and rectum showed less deposition of ova within their walls, as could be expected from the small percentage of schistosomes observed in their veins.

The presence of small haemorrhages from minute vessels was observed in the mucosa propria of the large intestine.

A microscopic examination of these revealed the presence of numerous schistosome ova, calcified or containing active miracidia.

The contents of this portion of the alimentary canal were in the majority of cases of normal consistence, but covered with bloodstained mucus. The microscopic examination of this mucus revealed the presence of small clots of blood holding schistosome ova. Most of the ova contained very active *miracidia*. In a few cases there was such an abundance of sticky mucus that the hard faecal pellets, lying more or less in a single row, could on section of the gut be removed *en masse*. Mucus, enveloping the pellets, was often observed hanging in a string from the anus. That the passage of firm faecal matter facilitates the liberation of ova from the mucosa must be accepted. It was frequently observed that attacks of constipation were followed by diarrhoea, the diarrhoea being quite probably a sequel to the invasion of the mutilated *mucosa propria* by bacteria.

No malignant or benign papillomatous growths as recorded for *S. bovis* in cattle and sheep (Khalil and Sonsino) or for *S. mansoni* and *S. haematobium* in man, were present in any one of the forty-five animals autopsied.

The microscopic appearances vary with the age of the infection.

In newly-invaded animals the ova lying in the venules (Fig. 29) were observed in fresh preparations made by scraping off the mucosa and examining it pressed between two glass slides. In sections, the ova were observed mainly in the *sub-mucosa* and passing through the *muscularis mucosa* into the *mucosa propria* (Fig. 23). In these various zones they were found surrounded by leucotypes (Fig. 35), especially small mononuclears, eosinophiles, and epithelial cells. The blood-vessels in the immediate neighbourhood appear slightly congested, and the mucous glands showed increased activity.

In cases of old standing, the most prominent lesion was the pronounced fibrosis of the wall of the digestive tube. The lesions observed were:—

(1) Schistosomes in pairs in the submucosa (Fig. 16), and occasionally in the subperitoneal veins.

(2) Pseudo-tubercles in different stages of development in the *mucosa propria* (Figs. 21, 23, and 24), in the *submucosa* (Figs. 22, 23, 24, and 25), and in the external and internal muscular layers (Figs. 21 and 22).

(3) Invasion and destruction of the *muscularis mucosa* (Figs. 21, 22, 23, and 24).

(4) Hyperaemia of the mucosa in some cases.
(5) Conspicuous absence of or a reduction in eosinophiles compared with those met with in the gut-wall of newly infected sheep.
(6) Hypertrophy of the walls of the veins.
(7) Increase of fibrous tissue in the invaded portions of the alimentary tract.
(8) The complete absence of tissues characterizing malignant growths.

Conclusions.

(i) No actual necrosis and erosions of the mucosa, as recorded from human cases infected with *S. haematobium*, *S. mansoni*, and *S. japonicum*, have hitherto been observed in sheep killed for autopsy. They were present in sheep that had succumbed after prolonged decubitus. It has already been suggested that some of the lesions attributed to schistosomiasis are secondary or attributable to bacterial, protozoal or metazoal invasion of the digestive tube.

(ii) The lesions observed in the alimentary tract of sheep prove that their production was stimulated by the presence of the parasites and their ova.

(iii) No malignant growths were encountered.

LIVER.

Macroscopic Appearance.

In cases of long standing the liver is decreased in size, of a shagreen appearance, and the surface may or may not be grossly lobulated (Fig. 3). In several cases the " hobnail " form of cirrhosis was observed. On palpation and on section the organ is extremely firm. The cut surface shows an increase of fibrous tissue in the portal tracts (Figs. 5 and 9). The cirrhosis is invariably of the multilobular type; occasionally areas showing monolobular cirrhosis were observed. The cut surfaces show dark pigmentation. In some cases a much lighter pigment in the perilobular tissues was discernible. The microscopic examination of fresh liver tissue showed that the latter pigmentation was due to deposited schistosome eggs.

In the more recently infected sheep the livers were markedly enlarged and of an abnormally pale colour; the consistence was slightly reduced; the surfaces smooth or nodular (Fig. 3); the cut surfaces showed the central veins open with the rest of the lobule somewhat opaque.

In a very recently infected lamb the liver showed a slight increase in size and numerous dull whitish specks under the capsule of both surfaces. Parasites were numerous in the portal vein and its ramifications.

Another type of liver met with was a heavily pigmented organ; increased in size with well-marked nodulation of both surfaces and with the consistence slightly reduced. In this type it would appear that the animal had become reinfected after cirrhosis; a sequel to a previous invasion had already been established.

In addition to these changes, the livers of some sheep showed calcified nodules of parasitic origin [*O. columbianum*, *Ecchinococcus granulosus* (cyst), and *Cysticercus tenuicollis*].

The more recent nodules due to *O. columbianum* were characterized by their greenish cheesy contents (eosinophiles accumulated in the vicinity of the migrating larva).

In the case of a ram which had died from intra-peritoneal haemorrhage of pancreatic origin, the bile-ducts appeared prominent owing to the thickening of their walls, stimulated by the presence of specimens of *Fasciola hepatica*.

In another case death followed as the result of a haemorrhage from the liver via the bile-duct into the duodenum. At post-mortem practically the whole of the small intestine was distended with coagulated blood.

In a ewe which had received intrajugular injections of a 6 per cent. solution of tartar emetic, the liver was enlarged and showed numerous emboli caused by dead schistosomes arrested in the hepatic ramifications of the portal vein.

Microscopic Appearances.

In the case of the atrophic cirrhotic liver, there is a marked increase of fibrous tissue in the portal tracts. The fibrosis is preceded by a cellular infiltration of these zones. Cellular accumulation is stimulated by the presence of the arrested ova (Figs. 5, 7, and 8).

Partially or completely organized thrombi (Fig. 6), practically obliterating veins, were frequently encountered. The walls of the viens show an increase of fibrous tissue. Pigment was as a rule present (i) in the immediate neighbourhood of the arrested ova, showing that it arrived there with the ova; (ii) in the lumen of the hepatic branches of the portal vein; (iii) in the *Stern cells* of Kupffner; and (iv) in the lumen of the central veins. It is undoubtedly via the liver that most of the pigment reaches the lungs.

Most of the eggs arrested in the liver showed calcification. In some cases (Fig. 5) the deposition of ova in the liver was heavy, but never so heavy as in the wall of the digestive tube (Figs. 13 and 14).

Fatty degeneration of the ova precedes calcification. *Giant cells* of the foreign body type were very seldom seen in the liver. Empty egg-shells were not encountered. Individual pseudo-tubercles were not so frequent as in the lungs and in the intestinal wall. In the recently invaded liver there were pseudo-tubercles showing different stages of development (Figs. 31, 32, and 33). The development of the pseudo-tubercle was observed to be as follows: an ova becomes arrested in a venule and may penetrate into the perivascular tissues; small nononuclears, endothelial cells, and eosinophiles surround it (Fig. 31); the included liver cells degenerate (Figs. 30, 32, and 33); eosinophiles which had penetrated to the egg perish there; fibroblasts begin and continue to develop until the necrotic mass is replaced by fibrous tissue and the egg is securely encapsulated and rendered harmless. Outside this developing capsule may occasionally be seen some eosinophiles, and small mononuclears and large endothelial cells containing pigment. Next to the egg may occasionally be observed a foreign-body giant cell (plasmodial mass). In no case was a giant cell found inside an egg-shell as recorded from human cases (Hutchison, 1928).

The structure of the pseudo-tubercle as seen in sections will vary with sections through it at different levels, and it is therefore best studied in serial preparations.

The microscopic examination of the liver of a sheep treated with tartar emetic showed that the emboli were due to dead schistosomes (Figs. 11 and 12). As in the lung (Fig. 25), the presence of these dead parasites stimulated cellular infiltration (Figs. 11 and 12).

The liver cells showed varying degrees of fatty degeneration. Degeneration was especially pronounced in cases of hypertrophic cirrhosis, but by no means uncommon in the atrophic form. The centre of the lobules often showed the liver cells deranged and degenerated, while the cells round the portal tracts appear unaffected (Fig. 35). There was an increase of connective tissue in the portal tracts. The chronic venous congestion of the liver contributed to the lesions referred to. The smaller bile-ducts were rather tortuous and showed proliferation of the endothelial cells.

Hepatic Cirrhosis.

According to most textbooks on Human Pathology, the liver in human schistosomiasis shows no contraction as in *alcoholic cirrhosis*. In some of the sheep autopsied there was a definite *polylobular* or *multilobular cirrhosis* and showing " hobnail " appearance (Fig. 3). In these cases the livers were enlarged and of a paler colour than normally. This slight yellowish discoloration was due to fatty changes.

That *atrophic cirrhosis*, *hypertrophic cirrhosis*, and intermediate forms were met with is proof that the one precedes the other. In a sheep infected for six months well-marked *hypertrophic cirrhosis* of the liver was encountered, while most of the old-standing cases showed a liver deeply pigmented, extremely firm, and with *atrophic cirrhosis* prominent. The livers, showing coarsely nodular bosses on the surfaces, were almost invariably hypertrophic. That these bosses result from the contraction of the fibrous tissue in an already enlarged liver is evident from the smooth-surfaced hypertrophic liver found in a six months infected sheep.

Taylor (1918), discussing atrophic and hypertrophic cirrhosis, mentions a case in which a liver reaching below the umbilicus, in a human with marked jaundice and no ascites, was found fifteen months later to have contracted quite close under the edge of the ribs.

In *malaria*, a protozoal disease characterized by the formation of a pigment, chemically indistinguishable from that produced by schistosomes, there is described a liver cirrhosis, monolobular in type and resembling the condition seen in alcoholic cirrhosis. Beattie and Dickson (1921) state that it is practically impossible, in any given case, to exclude all the other possible and well-recognized causes of cirrhosis and diagnose " Malarial cirrhosis."

Chronic hepatitis in domestic stock has been frequently recorded and has been ascribed to various causes. Observers have described cases where the *chronic hepatitis* in sheep, cattle, horses, and pigs was attributed to the migration of helminths.

Cysticercus tenuicollis and *Oesophagostomum columbianum* larvae (Figs. 43 and 44) in sheep; *Ecchinococcus granulosus* (cysts), *Fasciola hepatica*, and *F. gigantica* in sheep and cattle; *Strongylus*, *Habronema*, and *Parascaris equorum* larvae in equines; and *Ascaris* larvae in pigs, are in South Africa common causes of hepatic lesions.

Robertson (1906) in South Africa was able to produce atrophic cirrhosis of the liver in cattle and horses by feeding them repeated small quantities of *Senecio burchelli* and *S. latifolia*. Similar results were obtained by workers in North America and New Zealand with plants of the same genus. Other investigators suspect or have shown that toxins cointained in damaged (mouldy or rotten) food, toxius liberated during an attack of gastro-enteritis, toxins produced by helminths, bile stasis, chronic cholangioitis, and bacterial toxins and viruses are causal factors in the production of chronic interstitial hepatitis in our domestic stock.

Conclusions.

The changes in the livers of schistosome infested sheep should be attributed to:—

(1) the invasion by the developing schistosomes;
(2) the presence of eggs and exogenous pigment, of schistosome origin, arrested in the liver;
(3) the presence of dead adult schistosomes acting as emboli; and
(4) the chronic venous stasis.

That the cirrhosis may be partly due to a specific schistosome toxin cannot be completely ignored, but the present evidence seems to disprove its existence.

THE PANCREAS.

The pancreas in some cases showed a marked pigmentation of its more transparent portions. Pigmentation was due to deposited schistosome ova. In a number of cases the vessels were congested and contained schistosomes. In these cases the damage to the pancreas may have contributed to the fat necrosis observed.

Microscopically the pancreas showed marked changes from the normal. It was almost invariably involved. Eggs were recovered in all cases after the digestion of the organ in 4 to 5 per cent. caustic potash.

Sections revealed pseudo-tubercles, an increase in the amount of perilobular fibrous tissue, parasites in the veins, cellular accumulations around ova in the perilobular zones and those intralobularly located.

The Islets of Langerhans appeared normal. In heavily infected cases the walls of the veins were hypertrophied. Areas of the pancreas may appear degenerated (Fig. 36). In sheep the pancreas was undoubtedly more frequently involved than would appear to be the case in man. Dew (1923) observes that the pancreas is quite frequently involved in *S. mansoni* infections.

Judging from the habits of the different schistosomes, one would expect to find the pancreas more frequently invaded by *S. japonicum* and *S. mattheei* than by *S. mansoni*, and more often by the latter than by *S. haematobium*.

Fat Necrosis.

According to Osler (1916), fat necrosis in the human ". . . occurs whenever the pancreatic juice, obstructed for any cause and dammed back on the gland, infiltrates its tissues, or escaping by the lymph spaces finds its way to structures at some distance from the gland."

He further observes that Balsar was the first to record fat necrosis in the interlobular pancreatic tissue, in the mesentery, in the omentum, in the abdominal fatty tissue generally, and occasionally in the pericardial and subcutaneous fat.

These observations of Balsar on the human also hold for the sheep. In sheep the pericardial, the subepicardial, and the subendocardial fat is not infrequently involved. Fat necrosis may be generalized without the pancreas being involved.

Opie (1901) states that fat necrosis is due to the fat-splitting ferment present in the pancreatic secretion.

It seems definitely accepted by the medical profession that fat necrosis is invariably associated with lesions in the pancreas. It has been stated to be most frequent in the acute forms of pancreatitis and less common in the suppurative forms.

Moir (1929) reports on a case of traumatic fat necrosis of the breast, and records: "The lesion differs from the fat necrosis of pancreatitis in being of slow evolution, so that phagocytosis of fat-cell disintegration products and fibroblastic proliferation keeps pace with cell destruction."

This type of fat necrosis has been observed in the omentum of sheep infested with *O. columbianum*. Here the trauma was induced by the larvae of the parasite reaching the omentum.

Farr (1923) procured fat necrosis of the subcutaneous fat in young pigs by pinching the fat with forceps.

Gottesman and Zemansky (cited by Moir) have met with cases of fat necrosis in the breast although there was no history of trauma. They, therefore, conclude that there may be factors other than trauma, and express the view that the decomposition of fatty material, escaped from a dilated duct, may stimulate the lesions.

Lee and Adair (1920) were evidently the first to associate trauma with fat necrosis in the human breast.

That fat necrosis is by no means uncommon in domestic animals is evident from Hutyra and Marek (1920), who record that Marek and Ronai had both observed lobular fat necrosis of the pancreas in absolutely normal lobules in fattened pigs, and that Mettam and Prettner had reported cases in dogs. It is recorded as of exceptional occurrence in the horse. In the horse we have one of the larger strongyles passing a stage of its life-cycle in the pancreas.

Cleland and Darnell-Smith (1912) point out that fat necrosis is amongst the conditions that may occasionally be mistaken for tuberculosis. They substitute the term *fat dissociation* for the term *fat necrosis* and record that in New South Wales it is of common occurrence in apparently healthy cattle and sheep. In sheep the lesions were smaller than in cattle, where they were usually present in the fat around the kidneys and in the mesentery and the omentum. "In cattle these areas may be single and an inch or more in diameter, or there may be several smaller ones, or they may be multiple. They seem usually located towards the centre of the fat involved, and a varying degree of fibrosis and puckering surrounds them."

They then record that this fat dissociation in cattle has not been found associated with any pancreatic lesions as has been observed in humans.

As regards the etiology of this condition, they cite two possible explanations, namely:—

"According to one, the animal, as a consequence of luxuriant natural feeding, has stored up such an excessive amount of fat that the central areas of this substance are to all intents and purposes cut off entirely from the circulatory system, and are in much the same stage as the free fatty bodies mentioned as being sometimes found in the peritoneal cavity. . . . Under such conditions, presumably, the result would be autolysis of the cells, whose lymph supply has been diminished almost to the vanishing point, with the consequent appearance of fatty acid crystals within the cells, and the liberation of glycerine. It is to be noted in support of this view that the animals in which the condition occurs seem always to be in excellent health and remarkably fat.

According to the other view, during some previous period in the life of a fat bullock, a demand has been made by the tissues for fat; the stimulus has reached the central areas of the various collections of fat, which by means of lipase have split up fat into fatty acids and glycerine. This having been accomplished, however, the poor vascular and lymphatic supplies of the more central portions of the fat masses have rendered it impossible for the fatty acids set free to pass into the general circulation. Better conditions for the animal then happening to occur, such as the passing away of a period of drought or the advent of much nutritious food, the demand of the tissues for fat has ceased, and the process of storage of fat has again proceeded, now forming a deposit around the central masses of dissociated fat, that is, in those parts of the adipose tissue better supplied with nutrient fluids. This would lead to a process of encapsulation of the dissociated fat; and the presence of the fatty acid crystals, acting as a foreign body, would result in the formation of a certain amount of fibrosis of the connective tissue in the neighbourhood."

From the views held by various workers it is apparent that fat necrosis in man and animals may be provoked by different etiological factors. The findings of Hariot (cited by Cleland and Darnell-Smith, 1912) surely explain why fat necrosis may occasionally be encountered throughout all fat deposited in the body. In the cases of traumatic fat necrosis of the breast, in the young pigs of Farr, and in cases associated with parasitic invasion of the omentum, the fat necrosis should probably be attributed to serum lipase, the serum being liberated by the injured tissues. The multiple fat necrosis noted by Balsar and observed in sheep, heavily parasitized by endo- or ecto-parasites, at this Institute can only be explained by the presence of a fat-splitting ferment in the general circulation.

Fat necrosis was a common lesion in sheep autopsied by me at Pietermaritzburg in Natal, at Ermelo in the eastern Transvaal, on farms in the western Transvaal, on farms in the Fraserburg, Worcester, and Humansdorp Districts of the Cape Province, at this Institute, and on a farm near Arlington Station in the Orange Free State.

De Kock (1928 *a*), referring to cases seen at this Institute, reports that he has found no lesions in the pancreas, and could not understand how the fat-splitting ferment could have reached the fat deposited outside the peritoneal cavity. He concludes with the statement: "At present the pathogenesis and aetiology of fat necrosis in the sheep are still to be regarded as unsolved."

In the various cases observed, fat necrosis was invariably associated with one or combinations of the following conditions: mild gastro-enteritis, gastric strongylosis (*Haemonchus cortortus*, *Trichostrongylus axei*, *Ostertagia circumcincta*); intestinal strongylosis (*Trichostrongylus instabilis*, *T. rugatus*, *Gaigeria pachyscelis*, *Bunostomum trigonocephalum*, *Cooperia curticei*, *Ostertagia trifurcata*, *Nematodirus spathiger*, *O. columbianum*); bronchial strongylosis (*Dictyocaulus filaria*); fascioliasis (*Fasciola hepatica*, *F. gigantica*); schistosomiasis (*Schistosoma mattheei*); ascariasis (*Psoroptes communis*, var. *ovis*, *Sarcoptes scabei*, var. *ovis*, *Ornithodorus mégnini*); myiasis (*Oestrus ovis*, *Lucilia sericata*, *Chrysomyia albiceps*); *Globidium* species in abomasum, pediculosis (*Linognathus stenopsis* and *Trichodectes caprae*) in goats, and in forms of icterus (bacterial and enzootic).

It has, however, by no means been proved that only the fat-splitting ferment from the pancreas is wholly responsible for fat necrosis. Fat necrosis is invariably found in anaemia associated with metazoal parasites (ecto- and endo-parasites). The presence of large areas of necrosed fat in the immediate neighbourhood of the pancreas seems to show that also in sheep a fat-splitting ferment may diffuse into the adjacent fat. Multiple fat necrosis and fatty degeneration of the liver were constant pathological lesions in sheep which had succumbed to a heavy artificial infection with *Haemonchus contortus* or *Psoroptes communis*. The lesions were especially conspicuous in those animals which were in good condition at the time of infection.

The stable diet of the experimental sheep at this Institute is whole or crushed maize and veld hay. The latter, being of poor quality, is not consumed to any large extent. The sheep exist practically on maize alone, fatten rapidly, and accumulate large quantities of abnormally oily fat. In addition to this diet, they received, if available, a certain amount of green feed: lucerne, green oats, green barley, barley wheat, or maize ensilage according to season.

The components of the ration are given, as it may play a rôle although this does not seem very likely.

In addition, it may be stated that the animals are confined to camps in the open or to rather small pens in stables, where they are not in direct sunlight.

These factors may contribute to the anaemia which ultimately induces or facilitates fat necrosis.

More details concerning the cause of fat necrosis in dogs, cats, and cattle should be looked for in countries where helminths invading the pancreas occur. This recalls a case in which I recovered two specimens of *Fasciola hepatica* from the pancreatic duct in a sheep. The occurrence of this trematode in this habitat has to the best of my knowledge not been recorded hitherto. They evidently migrated here via the bile-duct.

In some animals the fat necrosis was most intense in the fat which had been in contact with the rumen (Fig. 46). This would seem to indicate that the necrosis may be attributed either to a substance, diffusing through the wall of the rumen, or to the pressure of the rumen on the adjacent deposits of fat. That pressure or trauma may contribute to fat necrosis is supported by the presence of necrosis in the subcutaneous fat at the point where the sides of the feeding-troughs press against the throats of the feeding animals. Some of the troughs are uncomfortably deep and the grain at the bottom is not too readily secured.

The anaemia produced by ecto- and endo-parasitic infestation is almost invariably accompanied by multiple fat necrosis throughout the body and by a fatty liver. Fatty degeneration of the liver is common in sheep heavily infected with *Haemonchus contortus*, a very active blood-sucking parasite inhabiting the abomasum. The anaemia produced leads to defective oxidation and causes the "white liver," a term commonly used by the South African sheep farmer in describing a fatty liver Fat necrosis always accompanies this fatty liver of *haemonchosis* and usually precedes it.

Fat necrosis, associated with parasitic infestation in the sheep, seems to result from a too rapid dissociation of fat when the demand on the stored fat is made to meet the requirements of the body. The ferment utilized to effect the dissociation of the fat is probably liberated in too large amounts into the general circulation. The fat is dissociated into fatty acids and glycerine. The glycerine passes into the blood-stream, while the fatty acids are partly neutralized, forming soaps. A recent analysis of necrosed fat by Professor Malan at this Institute revealed that the calcium had increased by thirty-three times the amount present in normal fat. Calcium was also present as calcium carbonate.

The determination of the etiology of fat necrosis rests undoubtedly in the hands of the biochemist. The pathologist may postulate hypotheses, but the biochemist will have to prove or disprove them.

My observations on fat necrosis are recorded in the hope that they may stimulate further interest in a condition apparently not uncommon in man and beast.

THE SPLEEN.

The Spleen was in some cases slightly enlarged, with the malpighian corpuscles rather prominent. In a few cases the organ was slightly pigmented and its veins contained a few schistosomes.

Various investigators—Day and Ferguson (1909), Tsuchiya (1913), Day (1924 and 1925), Fairley (1920), Houghton (1923), Dye (1925), Hodson (1925), Christopherson (1925), Melency (1925), and others—consider splenomegaly as one of the lesions associated with human schistosomiasis. This splenomegaly most of them attribute to toxins liberated by the schistosomes.

Hutchison (1928) states: "Splenic enlargement is commonly, but not constantly, associated with bilharzia infections." Melency (1925) believes that splenomegaly results from the plugging of thousands of portal capillaries in the liver, followed by scarring and contraction of the tissues. The splenic enlargement was therefore merely the results of an obstructed portal circulation. Houghton (1923) observes that great splenic enlargement is a common lesion with heavy infestations. He cites portal stasis as the main cause, but does not deny that toxix products of parasitic origin may play a part.

Splenomegaly was rarely observed in the schistosome-infected sheep killed for autopsy. In an animal, killed a month after intrajugular injections with tartar emetic had ceased, the spleen was markedly enlarged, and macroscopic and microscopic examination showed the presence of numerous verminous emboli in the ramifications of the portal vein. This suggests the inadvisability of forcing the tartar emetic treatment by frequently repeated large doses.

Finally, it may be recorded that at this Institute there are hundreds of sheep autopsied annually and that splenomegaly is by no means confined to any one disease. In one victim it may be well marked, whereas in another victim of the same disease it may be absent. Splenomegaly is quite common in healthy sheep killed at abattoirs. With Enzootic Icterus, an ovine malady of undetermined etiology and characterized by haemoglobinuria and general icterus, I have in victims autopsied at Ermelo (1925), in the eastern Transvaal, and at the Pietermaritzburg Municipal Abattoirs (1925), constantly found a markedly enlarged spleen. Recoveries from the disease were, contrary to De Kock's (1928 *c*) findings, high.

LUNGS.

Macroscopic Appearance.

Macroscopically the most conspicuous and constant lesion met with in the lungs was their characteristic discoloration. The colour closely resembles that of the liver as painted by Dr. J. K. Lund [in Byam and Archibald (1923), Pl. 68, Fig. 1].

This discoloration of the lungs was observed in every animal, but varied in intensity with the age and the degree of infection. The pigment, causing this characteristic discoloration of the lungs, is the unassimilated portion of the blood ingested by the schistosomes. This unassimilated ingesta is returned per os into the general circulation and is removed from the circulation chiefly by the *Stern cells* of Kupffner in the liver. The remaining portion is removed by the connective tissue cells in the alveolar wall of the lungs and to a much less extent by the periportal, the bronchial, and the mesenteric lymphatic glands.

Most (if not all) of the pigment conveyed to the lungs appears to be phagocytized before the venous flow is gained. This probably accounts for the relative absence of pigment in sections of such organs as the heart, the kidneys, the skeletal musculature, and the central nervous system.

The extreme ventral and caudal edges of the lungs may appear free of pigment (Fig. 40).

Microscopic Appearance.

A constant microscopic lesion met with in sections of the lungs is the presence of pigment in the connective tissue cells of the alveolar wall. Another lesion which was fairly constantly observed was the presence of pseudo-tubercles next to bronchioles. These pseudo-tubercles result from the arrest of eggs in the arterioles. This is followed by a cellular infiltration resulting in emboli formation and the total obliteration of the arteriole. The final result is typical pseudo-tubercles (Figs. 26, 27, 28, and 29), which may partly reduce the lumen of the bronchiole and lead to secondary changes in the lungs.

In the developing pseudo-tubercle, pigment may, in the early stages, be found quite close to the arrested egg or eggs. In the fully developed ones the pigment is absent, having been removed by phagocytes. Foreign-body giant cells were only occasionally met with and appeared to be less frequent than has been observed in man.

The pleura were in a few cases found somewhat thickened, but whether this was solely due to schistosomiasis is not evident, as these animals were also suffering from a *verminous broncho-pneumonia*.

In the case of animals which had received intrajugular injections of drugs lethal to schistosomes, numerous parasites were found in the pulmonary arteries. These parasites were very much reduced in size, and the females harboured in their uteri rather small abnormally shaped eggs (Fig. 45).

The lungs of an animal which had received tartar emetic showed dead schistosomes arrested in the smaller arteries of the lung. The dead parasites stimulated cellular infiltration (Fig. 30).

Nasal discharges were examined for eggs, but none were ever found.

Comparison with the Lesions recorded for Man.

The comparative absence (according to the literature) of lung lesions in man must be attributed to the lack of looking for them.

There are, however, a few references. Mackie (1885) and Bellili (1885) observed schistosome eggs in numerous small abscesses in the lungs. Eyles (1888), Bowlbey (1889), and Kartulis (1913) likewise record the presence of ova in the lungs. Symmers found a pair of worms in copula in the blood from the lung. Manson (1905) has observed ova in small numbers in the lungs, as did Pakes (Turner, 1908) in South Africa. Turner (1908) recorded lateral-spined ova from the lung of a Shangaan who had died of a nodular condition of the liver. This condition Turner attributed to either tuberculosis or syphilis. Out of 59 humans examined at post-mortem eggs were noted in the lungs of 37 and in the bladders of 52. In Byam and Archibald we have the lines: "Rarely in advanced and hyper-infected *S. haematobium* cases haemoptysis has been recorded with terminal-spined ova in the sputum." Dew (1923), discussing the lesions observed in the human lungs, records that in pure *S. mansoni* infection there is an almost complete absence of lung changes, in contrast to the lesions (pigmentation and patchy fibrosis) found in association with *S. haematobium* invasion. He suggests that the eggs reach the lungs either via the liver or through anastomatic channels between the portal and systemic systems.

Hutchison (1928) refers to the lungs in the brief statement: "Ova have been discovered in the lungs, brain, and kidneys."

With a progressive cirrhosis of the liver, the flow of blood through the organ is obstructed and the radicles of the portal vein become distended. The spleen is, therefore, often swollen. The increase of the pressure in the portal circulation is partly relieved by the widening of the anastomoses between the tributaries of the portal vein and those of the posterior vena cava. MacCallum (1919) points out that anastomoses between the portal and the systemic circulation are well described by Charcot (1882).

Conclusions.

Judging from the observations on sheep, it would appear that—

(1) the pathological lesions in the lungs are provoked by the presence of ova, pigment, and the parasites (migrating immature forms and dead adults);

(2) the lungs in *S. mattheei infection* are more often affected than with *S. mansoni* (a form of intestinal schistosomiasis) in man;

(3) the pigment which is not removed by the liver is removed by the lungs;

(4) the pigment and schistosomes may reach the lungs via the liver or via anastomoses widened as a result of the hepatic cirrhosis.

LYMPH GLANDS.

The most commonly affected lymph glands were the pancreatic, the hepatic, and the mesenteric. These were, as a rule, slightly enlarged and had the cortical zone heavily pigmented with a pigment chemically indistinguishable from the malarial pigment. The medulla of the mesenteric lymph glands often showed the presence of pseudotubercles. The presence of worms in these glands explains the presence of ova, while the pigment arrived here from the wall of the invaded intestine. The bronchial lymph glands were occasionally pigmented.

THE BLOOD CHANGES.

The marked eosinophilia recorded for schistosome-infected humans was not observed. This may perhaps be due to the fact that the disease was chronic. Several of the sheep were also infected with *Dictyocaulus filaria*, the only lungworm hitherto observed in South African sheep. The lungworm-infected sheep did not show an eosinophilia either, although portion of the lungs, on microscopical examination, showed heavy infiltration with eosinophiles. The bone-marrow did not show changes from the normal. This would lead one to deduct that the eosinophiles were formed from lymphocytes present at the lesion.

TOXINS EXCRETED BY SCHISTOSOMES.

According to Dew (1923), schistosomes " produce a toxin the reaction to which is manifested by eosinophilia and deviation of complement, and which is probably a big factor in the production of many of the pathological changes, especially those found in the liver."

Fairley (1920) states that the circulating toxins liberated by *S. mansoni* and *S. haematobium* are filtered out into the periportal zones. He attributes the generalized periportal cirrhosis of the liver to this toxin rather than to the presence of the ova.

Hutchison (1928) concludes that schistosomes produce "noxious substances" in the body of the host. According to him, "the nature of this noxious substance is not clearly established." He advances facts to prove that it results from simple protein splitting rather than from toxin production.

The presence of toxins liberated by the parasites themselves or by their ova has to my mind not been indisputably established. The fact that hyper-infected monkeys died does not necessarily prove the existence of toxins primarily produced by the schistosomes.

TOXINS ATTRIBUTED TO OTHER OVINE PARASITES.

There still seems to be a tendency to attribute the ill-effects elicited by helminths to "toxins" produced by them.

De Kock (1928), discussing *Haemonchus contortus* (the common stomach-worm) and *Oesophagostomum columbianum* (the nodular worm) infesting sheep, writes: "The worms live on blood (haemonchus) or produce poisonous substances (oesophagostomum)." This sweeping statement, unsupported by experimental data, is misleading and cannot be accepted, especially when Curtice (1890), the original discoverer of *O. columbianum*, states that the parasites are attached to the membrane of the large intestine and cause lesions in various organs.

Theiler (1921), in an admirable article on the ravages and lesions caused by the nodular worm of sheep, records the finding of worms attached to the mucous membrane of the large intestine. Mönnig (reprint from *Northern News*, Vryburg), discussing *O. columbianum*, writes: "The worms are not attached to the wall of the intestine, but lie mixed up with the contents." "These worms are not blood suckers." My personal observations support the findings of Curtice and Theiler.

The lesions observed in various organs (wall of small and large intestines, liver, omentum, mesenteric lymphatic glands, etc.) prove that the parasitic larval stage of this nematode is capable of inflicting considerable damage to tissues. There is no proof that the tissues, thus damaged, are not at some stage the producers of noxious substances.

That the migration of schistosome cercariae, adult schistosomes and their ova within the host, can damage the tissues is evident. That the damaged tissues cannot provoke the reactions observed has not been proved, but neither has it been disproved. The work of Lewis (1927) seems to support the view that stimulated or damaged tissues are capable of liberating irritants.

Geurrini (1912), dealing with the influence of trematode parasites on man, concludes that there is little evidence of toxin production. Several workers [Bedson (1913), Paulin (1914, Meyer (1913), Seyderhelm, and others] by injecting various worm extracts into experimental animals have provoked clinical symptoms or have induced pathological lesions in internal organs. These they attribute to toxins contained in the injected materials. They did not appear to have taken into consideration the nature of the substances injected.

With the advance of biochemistry this " Toxin theory " may one day be proved or disproved. In the meantime we have to accept Nicoll's (1922) lines: " Geurrini, on the other hand, does not appear to deny that pathogenic action may result from mechanical irritation, from the withdrawal of material essential to the host's economy, and from the promotion of secondary infection."

In South Africa the losses from the majority of gastro-intestinal parasites of sheep and cattle are seasonal and are most severe in a given locality when the natural grazing in that locality is at its worst.

The rapid disappearance of *Oesophagostomiasis* this spring from the flocks of the western Transvaal and Bechuanaland at the appearance of green pastures, after the first rains, proves to my mind that " the withdrawal of material essential to the host's economy " is a most important factor to be considered in the fight against parasitic diseases.

My personal observations are that sheep in good condition, kept on a well-balanced ration and free of other diseases, can only with difficulty be killed by infecting them with one species (*Dictyocaulus filaria, Schistosoma mattheei, Haemonchus contortus, Oesophagostomum columbianum*, or *Trichostrongylus*) at a time.

In some cases (*Dictyocaulus* and sheep, and *Haemonchus* and calves) it was impossible to infect animals in good condition. In others the infection was established only to be lost again within a short time. On reducing the rations of these animals they became infected. These infected animals were saved, provided they were not too heavily infected, by putting them back on to well-balanced rations. They increased in weight and lost the infection.

These experiments, conducted only with a few species, seem to indicate that animals in good condition possess the power of protecting themselves against certain helminths, and that infected animals when properly cared for can rid themselves of these worms.

In the case of *Schistosomiasis* my observations, based on field and laboratory experience, prove that infected sheep, on good pastures or on a balanced ration, relatively free from other helminths or ectoparasites and not unnecessarily worried, will not, during the productive period of their short span of life, die as the result of *S. mattheei* infestation. Records suggest that even in man schistosomiasis is a remarkably benign malady. The cases recorded as having been fatal within a few years occurred undoubtedly in malnutritioned, overworked, or otherwise debilitated individuals. Malnutritioned children, overworked, ill-clad, and underfed agricultural labourers, and already diseased subjects are likely to be very adversely affected by schistosome invasion. The successful control, prevention, and eradication of tropical diseases depend on better hygiene, less fatigue, and more suitable food.

That much of the injury caused by parasites is indirect, cannot be disputed. Do they unintentionally predispose their keepers' tissues to bacterial invasion or do they initiate this invasion as a defence against total extermination?

Galli-Valerio's (1914) remarks, that the attention paid to bacteriology has unduly distracted attention from the pathogenic propeties of worms, still hold to-day. We must, however, admit that the time and energy devoted to bacteriology has furnished us with some valuable data, to be applied in the investigation of the pathogenic properties of helminths.

If the future attempts at the control and the eradication of parasitic diseases are to be successful, there should be closer co-operation between Biochemists, Pathologists, Bacteriologists, and Parasitologists.

Other Helmints collected from the Sheep infected with Schistosomes.

In addition to *Schistosoma mattheei*, there were present (not necessarily all in any one animal) the species:—

Paramphistomum calicophorum in the rumen;
Fasciola hepatica (one case) in the bile and pancreatic ducts;
Haemonchus contortus, *Ostertagia circumcincta*, *Trichostrongylus axei*, and *T. instabilis* in the abomasum;
T. instabilis, *T. rugatus*, *Ostertagia furcata*, *Nematodirus spathiger*, *Bunostomum trigonocephalum*, *Strongyloides papillosus*, *Oesophagostomum columbianum* (nodules in gut-wall), *Avitellina centripunctata*, and *Moniezia expansa* in the small intestine;
Trichocephalus ovis, *O. columbianum*, in lumen of caecum and rest of large intestine;
O. columbianum nodules in gut-wall not too frequent;
Cysticercus tenuicollis in subperitoneum;
Ecchiococcus granulosus (cysts) in liver and lungs;
Dictyocaulus filaria in bronchi and bronchioles; and
Gongylonema scutatum in the mucosa of oesophagus.

The sheep which were dying were those simultaneously heavily infested with *H. contortus* and *Dictyocaulus filaria*. The former was successfully removed by the use of the Government Wireworm Remedy (a mixture of powdered copper suphate 80 per cent. and arsenic 20 per cent.).

In well-fed animals the lung-worm infection was lost within six to nine weeks after arrival at the laboratory. By keeping the animals on short rations the infection was retained.

Helminths collected from Small Antelopes shot in the Endemic Area.

One adult bushbuck (*Tragelaphus sylvaticus*) and three steenbucks (*Raphiceros campestris* Hunb.) were examined. The bushbuck yielded only three specimens of *Setaria* and from the steenbucks were collected only a few specimens of *H. contortus* and *T. rugatus*. The recovery of the latter from a wild ruminant, and its record hitherto from sheep in South Africa only, suggest that wild ruminants are the natural hosts.

ACKNOWLEDGMENTS.

The writer wishes to thank the Director and his colleagues for the interest shown; his friend, Dr. F. Veglia, for suggestions and for

lending him a copy of the article by Dr. Bertolini. To Mr. T. Meyer he is indebted for the preparation of the many microphotographs. Mr. A. Verbeke, the librarian, is thanked for his valuable assistance in helping to trace the literature available in South Africa. Mr. Pieterse, my laboratory assistant, is remembered for his eagerness.

BIBLIOGRAPHY.

ASCANIO RODRIQUEZ, J. B. (1915). "Sobre un caso de *Bilharziasis hepatica*," *Gaceta Med. de Caracas.*, Vol. 22, No. 19, pp. 147-149. (Reviewed in *Trop. Dis. Bull.*, Vol. 7, No. 6, pp. 352-353.)

BAHR, P. MANSON, AND FAIRLEY, N. H. (1920). "Observations on Bilharziasis amongst the Egyptian Expeditionary Force," *Parasit.*, Vol. 12, pp. 33-71.

BALDREY, F. S. H. (1906). "Some Problems in Sheep Diseases," *Jl. Trop. Vet. Sc.*, Vol. 1, No. 4, pp. 388-397.

BALFOUR, A. (1928). "A Schistosome Dermatitis," *Trans. Roy. Soc. Trop. Med. and Hyg.*, Vol. 22, No. 1. pp. 92-93.

BEATTIE, J. M., AND DICKSON, W. E. C. (1921). "Special Pathology," pp. 803-809 and 824-828. (W. Heinemann, Ltd., London.)

BEDSON, S. P. (1913). "Lésions des Organes à secrétions interne dans l'intoxications vermineuse," *Ann. Inst. Pasteur*, Vol. 27, pp. 682-699.

BELLELI, V. (1885). "Les oeufs de *Bilharzia haematobia* dans les poumons," *Union Med. Egyp.*, Alexandria, T. I., pp. 1-3.

BEQUAERT, J. (1928). "Mollusks of Importance in Human and Veterinary Medicine," Parts 1 and 2, *Amer. Jl. Trop. Med.*, Vol. 8, Nos. 2 and 3, pp. 165-182, 215-232.

BONNIN, H. (1928). "Splénomégalie et bilharziose intestinale. Splénomégalie egytienne," *Gaz. hebd. Sci. Méd. de Bordeaux*, Vol. 49, Nos. 25 and 26, pp. 387-396, 403-413. (Reviewed *Trop. Dis. Bull.*, Vol. 25, No. 12.)

BOWLBEY, A. A. (1889). "Organs and Parasites from Cases of *Bilharzia*," *Trans. Path. Soc.*, London, Abstract in *Brit. Med. Jl.*, Vol. 1, p. 891.

BOWLBEY, A. A. (1891). "Specimens of *Distoma haematobia* with the Urinary Organs and Lungs containing Ova," *Trans. Path. Soc.*, London, Vol. 42, pp. 194-195.

BROWN, W. H. (1911). "Malarial Pigment (so-called Melanin), Its Nature and Mode of Production," *Jl. Exper. Med.*, No. 13, pp. 290-299.

BRUMPT, E. (1927). "Précis de Parasitologie," pp. 467-506. (Masson & Cie, Paris.)

BYAM, W., AND ARCHIBALD, R. G. (1923). "The Practice of Medicine in the Tropics," Vol. 3, pp. 1712-1788. (Frowde and Hodder & Stoughton, London.)

CADE, MORENAS, ET JEANNIN (1928). "De l'enfluence des toxines vermineuses sur 'levolution de la tuberculose experimentale," *Jl. Physiol. et Path. Gén.*, Vol. 26, No. 2, pp. 250-255.

CARADINI (1908), BERTOLINI, G. "Osservazioni sulla *Bilharzia crassa* (*Schistosomum bovis*) e sulle alterazion da esaa prodotte" (*La Clin. Veter.*, 1908, No. 1.) *Centralbl. f. Bakt.*, etc., 1 abt. *Referate*, Vol. 41, No. 19/21, pp. 669-671.

CATTO, J. (1905). "*Schistosoma cattoi*, A New Blood Fluke," *Brit. Med. Jl.*, Vol. 1, pp. 11-13.

CAWSTON, F. G. (1915). "Bilharziosis in Natal," *Brit. Med. Jl.*, Nov., Vol. 20, p. 746.

CAWSTON (1920). Quoted by Faust (1926).

CAWSTON, F. G. (1925). "The Identity of the Rarer Schistosomas of Man and Their Intermediate Hosts," *Ann. Trop. Med. and Parasit.*, Vol. 19, No. 2, pp. 215-218.

CHENG FANG TSU (1925). " Ueber den acuten Milztumor bei *Schistosomiasis Japonica*," *Far East Assoc. Trop. Med., Trans. Sixth Biennial Congress, Tokyo*, 1925, Vol. 1, pp. 465-466.

CHOPRA, R. N., AND CHANDLER, A. C. (1928). " Anthelminthic and Their Uses," pp. 37-38, 54, and pl. 3, fig. 36. London.

CLAPIER (1926). " Les Bilharzioses dans la Region militaire de la Guinee," *Bull. Soc. Path. Exot.*, Vol. 9, No. 9, pp. 739-747.

CLELAND, J. B., AND DARNELL-SMITH, G. P. (1912). " Fat Dissociation in Cattle and Sheep," *Second Report, Government Bureau of Microbiology*, New South Wales, pp. 107-109. (*Vide Jl. Comp. Path. and Therap.*, Vol. 23, 1910, p. 177.)

COCKAYNE, E. A. (1921). " Liver Cirrhosis," *The Dictionary of Practical Medicine*, edited by Morris, Langmead, and Holmes, pp. 210-216. (Waverley Book Co., Ltd., London.)

COLEMAN, R. B. (1926). " Egyptian Splenomegaly, and Its Relation to Schistosomiasis," *Trans. Roy. Soc. Trop. Med. and Hyg.*, Vol. 20, No. 3, pp. 224-227.

COVENTRY, F. A., AND TALIAFERRO, W. H. (1927). " Hypersensitiveness to Helminth Proteins. Cutaneous Tests with Proteins of Ascaris, Hookworm, and Thrichuris in Honduras," *Sixteenth Ann. Rep. Med. Dept. United Fruit Company, Boston, Mass.*, pp. 219-232. (Reviewed *Trop. Dis. Bull.*, Vol. 25, No. 12.)

DAY, H. B. (1911). " The Blood Changes in Bilharziasis, with Special Reference to Egyptian Anaemia," *Lancet*, pp. 1328-1332.

DAY, H. B. (1924). " The Etiology of Egyptian Splenomegaly and Hepatic Cirrhosis," *Trans. Roy. Soc. Trop. Med. and Hyg.*, Vol. 18, No. 3, pp. 121-130.

DE KOCK, G. (1928 *a*). " Fat Necrosis in Sheep," *S. Afr. Jl. Sc.*, Vol. 25, pp. 270-273.

DE KOCK, G. (1928 *b*). " Diseases of Sheep in Relation to the Pasture under South African Conditions," *Jl. S. Afr. V. M. Assoc.*, Vol. 1, No. 2, pp. 29-38.

DE KOCK, G. (1928 *c*). " A Study of the Reticulo-endothelial System of the Sheep, 13*th and* 14*th Reports, Dir. Vet. Educ. and Res.*, Part 1, pp. 647-726. (Dept. Agric., Pretoria.)

DEW, H. R. (1923). " Observations on the Pathology of Schistosomiasis (*S. haematobium* and *S. mansonii*) in the Human Subject," *Jl. Path. and Bact.*, Vol. 26, No. 1, pp. 27-39.

DIAMANTIS (1928). " Le parasite bilharzien possede-t-il chez l'homme un stage hepatique," *Jl. Egypt. Med. Assoc.*, June, Vol. 2, No. 6, pp. 212-249.

DYE, W. H. (1925). " Schistosomiasis and Splenomegaly in Nyasaland," *Proc. Roy. Soc. Med.*, Vol. 19, No. 8, Sect. Trop. Dis. and Parasit, pp. 44-45.

EYLES (1888). " *Bilharzia haematobium* in West Africa," *Lancet*, Vol. 2, p. 659.

FAIRLEY, N. H. (1919). " Egyptian Bilharziasis: Its Recent Pathology, Symptomatology, and Treatment," *Proc. Roy. Soc. Med.*, Occ. Lect., 13, p. 1.

FAIRLEY, N. H. (1919). " Bilharziasis: Some Recent Advances in our Knowledge," *Lancet*, pp. 1016-1020.

FAIRLEY, N. H. (1920). " A Comparative Study of Experimental Bilharziasis in Monkeys, contrasted with the hitherto described Lesions in Man," *Jl. Path. and Bact.*, Vol. 23, No. 3, pp. 289-314.

FAIRLEY, N. H., AND MACKIE, F. P. (1925). " A Preliminary Report on the Pathology of *Schistosomum spindalis*," *Far Eastern Assoc. Trop. Med., Trans. Sixth Biennial Congress, Tokyo*, Vol. 1, pp. 423-446. (Reviewed *Trop. Dis. Bull.*, Vol. 24, No. 3.)

FAIRLEY, N. H. (1926). " Studies in the Chemotherapy and Immunity Reactions of Schistosomiasis," *Trans. Roy. Soc. Trop. Med.*, Vol. 20, No. 4, pp. 236-267.

FAIRLEY, N. H., AND JASUDASIN (1927). "The Experimental Transmission of *S. spindalis* to the Indian Water Buffalo," *Indian Jl. Med. Res.*, Vol. 14, No. 3, pp. 701-706.

FAUST, E. C. (1919). "Notes on South African Cercariae," *Jl. Parasit.*, Vol. 5, pp. 164-175; 1 pl.

FAUST, E. C. (1920 *a*). "Criteria for the Differentiation of Schistosome Larvae," *Jl. Parasit.*, Vol. 6, pp. 192-194.

FAUST, E. C. (1920 *b*). "A Survey of Cawston's Species of South African Cercariae," *Parasitology*, Vol. 12, pp. 211-216.

FAUST, E. C. (1921). "Notes on South African Larval Trematodes," *Jl. Parasit.*, Vol. 8, No. 1, pp. 11-21; 13 figs.

FAUST, E. C. (1926). "Further Observations on South African Larval Trematodes," *Parasit.*, Vol. 18, No. 1, pp. 101-127.

FAUST, E. C. (1927). "The Possible Presence of Male Schistosomes alone in Experimental and Natural Infections," *Jl. Parasit.*, Vol. 14, No. 1, pp. 72-63.

FERGUSON, A. R. (1911). "Associated Bilharziasis and Primary Malignant Disease of the Urinary Bladder, with Observations on a Series of 40 Cases," *Jl. Path. and Bact.*, Vol. 16, pp. 76-

FERGUSON, A. R. (1913). "The Lesions of Bilharzial Disease," *Glasgow Med. Jl.*, Vol. 79, No. 14.

FLEMING, G. (1892). "Neumann's Parasites and Parasitic Diseases of Domesticated Animals," pp. 632-633. (Baillière, Tindall & Cox, London.)

FLURY, F. (1913). "Beitrage zur chemie und Toxicologie der Trichinen," *Arch. Exper. Path.*, Leipzig, pp. 164-213.

GARIN, C. (1913). "Recherches physiologiques sur la fixation et la mode de nutrition de quelques Nematodes parasites du tube digestief de l'homme et des animaux," *Ann. Univ. Lyon*, Vol. 34, p. 160.

GONZALEZ, M. I. (1916). "Investigations on the Prevalence and Clinical Features of Intestinal Bilharziosis (*Schistosomiasis mansoni*) in Porto Rico," *New Orleans Med. and Surg. Jl.*, Vol. 69, No. 5, pp. 352-394. (Reviewed *Trop. Dis. Bull.*, Vol. 9, No. 6, pp. 269-270.)

HOARE, E. W. (1915). "A System of Veterinary Medicine," Vol. 2, pp. 1508-1509. London.

HODSON, V. S. (1925). In discussion of Dye's (1925) article, p. 54.

HOUGHTON, H. S. (1910). "Notes on Infections with *Schistosomum japonicum*," *Jl. Trop. Med. Hyg.*, Vol. 13, No. 12.

HOUGHTON (1923). "Schistosomiasis of the Far East (*Schistosoma japonicum*)," in Byam and Archibald's *Practice of Medicine in the Tropics*, Vol. 3, pp. 1773-1788.

JOYEUX, CH. (1927). "Précis de Médecine coloniale." (Masson et Cie, Paris.)

KAUPP, B. F. (1918). "Animal Parasites and Parasitic Diseases," p. 169. Chicago.

KHALIL, M. (1924). "On the Morphology of *Schistosoma bovis*," *Jl. of Helm.*, Vol. 2, No. 2, pp. 81-86.

KNUTH, P., UND DU TOIT, P. J. (1921). *Tropen-Krankheiten der Haustiere*, pp. 846-848. (Johan Ambrosius Barth, Leipzig.)

LAMBERT, R. A., AND BURKE, A. M. B. (1928). "Studies on Schistosomiasis (*S. mansoni*) in Porto Rico. IV: Correlation of Clinical and Autopsy Findings with Case Reports," *Porto Rico Rev. of Public Health and Trop. Med.*, Vol. 3, No. 10, pp. 403-415. (Reviewed *Trop. Dis. Bull.*, Vol. 25, No. 12.)

LEESE, A. S. (1911). "Bilharziosis in the Camel," *Jl. Trop. Vet. Sc.*, Vol. 6, No. 3, pp. 263-264.

LEESE, A. S. (1927). "One-Humped Camel in Health and Disease." (Stamford, Lincolnshire.)

LAMPE, P. H. J. (1927). "The Development of *Schistosoma mansoni*," *Proc. Royal Soc. Med.*, Vol. 20, No. 9, pp. 1510-1516.

LAMPE, P. H. J. (1926). "Pathologisch anatomische Veranderungen bei *Bilharziasis mansoni*," *Arch. f. Schiffs. u. Trop.-Hyg.*, Vol. 30, No. 9, pp. 475-484.

LANING, R. H. (1914). "Schistosomiasis on the Tangtze River, with Report of Cases," *U.S. Naval Med. Bull.*, Vol. 8, No. 1, pp. 16-36. (Reviewed in *Trop. Dis. Bull.*, Vol. 9, No. 6.)

LEIPER, R. T. (1915). "Report on the Results of the Bilharzia Mission in Egypt," *Jl. Roy. Army Med. Corps*, Vol. 25, No. 1, pp. 1-55; No. 2, pp. 147-192; No. 3, pp. 253-267.

LEIPER, R. T. (1923). "Medical Helminthology: A Review" (Part I), *Trop. Dis. Bull.*, Vol. 20, No. 11, pp. 857-853.

LEIPER, R. T. (1924). "Present-day Teachings on Helminthology in Relation to Public Health," *Brit. Med. Jl.*, July 19th, pp. 110-113.

LETULLE, M. (1905). "Bilharziose Intestinale," *Arch. de Parasit.*, Vol. 9, No. 3, pp. 329-439.

LOOSS, A. (1908). "What is *Schistosomum mansoni* Sambon, 1907?" *Ann. Trop. Med. and Paras.*, Vol. 2, No. 3, pp. 151-191.

LOOSS, A., EN KARTULIS (1913). "Die Bilharzia-krankheit. Zoologische und medizinische Teil," in Kolle und Wassermann's *Handbuch der pathogenen Mikroorganismen*, pp. 1-40.

LUTZ, A. (1919). "O *Schistosomum mansoni* e a Schistosomiasis segundo observacoes feitas no Brazil," *Mem. Inst. Oswaldo Cruz.*, Vol. 11, pp. 121-155.

MACIEL, H. (1926). "A influencia das forcas cosmicas sobre a postura do *Schistosoma mansoni*," *Sciencia Med.*, Vol. 4, No. 11, pp. 588-594.

MADDEN, F. C. (1910). "The Incidence of Bilharziasis in Egypt and its Clinical Manifestations," *Brit. Med. Jl.*, Vol. 2, p. 965.

MAHFEZ, A. H. (1927). "A Case of *Schistosoma bovis* in Man," *Egyptian Med. Rev.*, pp. 301-306 (in Arabic). (Reviewed *Trop. Dis. Bull.*, Vol. 25, No. 12.)

MANN, W. L. "Some Practical Aspects of Schistosomiasis as found in the Orient: Preliminary Report," *Jl. Amer. Med. Assoc.*, Vol. 67, No. 19, pp. 1366-1368. (Reviewed *Trop. Dis. Bull.*, Vol. 9, No. 6, pp. 268-269.)

MAROTEL, G. (1927). "Parasitologie Veterinaire," pp. 119-120. (J. B. Baillière et Fils, London.)

MARTINEZ, I. (1928). "Studies on Schistosomiasis in Porto Rico," *Porto Rico Rev. Public Health and Trop. Med.*, Vol. 3, No. 11, pp. 443-457.

MELENY, H. E. (1925). In discussion of Dye's (1925) article, pp. 53-54.

MEYAGAWA, Y. (1913). "Ueber den Wanderungsweg des *Schistosomum japonicum* durch Vermittlung des Lymphgefossystem des Wirtes," *Centralbl. f. Bakt.* 1 *Abt. Orig.*, Vol. 68, No. 2, pp. 204-206.

MONTGOMERY, R. E. (1906 *a*). "Observations on Bilharziosis among Animals in India: I," *Jl. of Trop. Vet. Sc.*, Vol. 1, No. 1, pp. 15-46.

MONTGOMERY, R. E. (1906 *b*). "Observations on Bilharziosis among Animals in India: II," *Jl. Trop. Vet. Sc.*, Vol. 1, No. 2, pp. 138-153.

MOIR, P. J. (1929). "Traumatic Fat Necrosis of the Breast," *Brit. Med. Jl.*, No. 3561, pp. 640-641.

NEUMANN, L. G. (1914). "Parasites du Chien et du Chat," pp. 298-299. Paris.

OSLER, W., AND McCRAE, T. (1918). "The Principles and Practice of Medicine," pp. 283-284, 575-582, 593, and 888. (Appleton & Co., New York and London.)

PAULIAN, D. E. (1918). "Parasitisme et Eosinophilie," *C.R. Soc. Biol.*, Vol. 78, pp. 155-156.

PEAKE, E. C. (1912). "Additional Notes on the Egg of *Schistosomum japonicum*," *China Med. Jl.*, Vol. 26, No. 6, pp. 350-352. (Reviewed by R.T.L. in *Trop. Dis. Bull.*, Vol. 2, No. 4.)

PILOD, CODVELLE, ET HYGONOT (1928). "Un cas de splénomégalie d'apparance primitive d'origine distomienne," *Bull. et Mém. Soc. Méd. Hôpit. de Paris*. Vol. 52, No. 1, pp. 18-25. (Reviewed *Trop. Dis. Bull.*, Vol. 25, No. 6.)

PORTER, A. (1926). "Notes on the Structure and Life-history of a Variety of *Schistosoma spindalis* Montgomery observed in South Africa," *S. Afr. Jl. Sc.*, Vol. 23, pp. 661-666.

RACHMANOV (1914). "Lésions du système nerveux dans l'intoxication vermineuse," *Ann. Inst. Pasteur*, Vol. 28, p. 181.

ROBERTSON, A. R. (1916). "Case Reports from the Army Medical Services: I. Bilharzias," *Canadian Med. Assoc. Jl.*, Vol. 6, No. 10, pp. 913-914.

ROBINSON, E. M. (1928). "Preliminary Investigations into an Icterus of Sheep caused by a Bacterium (*Bacterial Icterus*)," 13 *and* 14*th Reports, Dir. Vet. Educ. and Res.*, Part II, pp. 733-741. (Dept. Agric., Pretoria.)

ROGERS, L. (1908). "A Peculiar Intralobular Cirrhosis of the Liver produced by the Protozoal Parasite of Kala-Azar," *Ann. of Trop. Med. and Paras.*, Vol. 2, No. 3, pp. 147-152.

RUFFER, M. A. (1910). "Note on the Disease of *Bilharzia haematobium* in Egyptian Mummies of the 20th Dynasty," *Brit. Med. Jl.*, Jan. 20th.

SEVERINGHANS, A. E. (1928). "Sex Studies on *Schistosoma japonicum*," *Quart. Jl. Microscop. Sci.*, Vol. 71, Pt. 4, N.S. No. 284, pp. 653-702.

SOBHY, M. (1923). "Bilharziasis of the Conjunctiva," *Jl. Egypt. Med. Assoc.*, Vol. II, No. 1, pp. 12-15.

SYMMERS, W. ST. C. (1903). "Note on a New Form of Liver Cirrhosis due to the presence of Ova of *Bilharzia haematobia*," *Jl. Path. and Bact.*, Vol. 9, pp. 237-

SYMMERS, W. ST. C. (1905). "Note on a Case of Bilharzia Worms in the Pulmonary Blood of a Case of Bilharzial Colitis," *Lancet*, Vol. 1, p. 22.

THEILER, A. (1921). "The Nodular Worm and the Lesions caused by it," *Jl. Dept. Agric., South Africa*, Reprint No. 1.

TURNER, G. A. (1908). "Pulmonary Bilharziosis in South Africa," *Transvaal Med. Jl.*, Vol. 4, No. 5, pp. 107-110.

TURNER, S. W. (1919). "Pulmonary Bilharziosis," *Jl. Trop. Med. and Hyg.*, Vol. 12, No. 3, pp. 35-36.

TSUCHIYA (1913). "Clinical, Pathological-Anatomical, Pathogenic, Prophylactic and Therapeutic Study of the *Schistosomiasis japonica*," *Jl. Tokyo Med. Assoc.*, Vol. 27, No. 10. (Reviewed by R.T.L. in *Trop. Dis. Bull.*, Vol. 2, No. 8, pp. 406-407.)

UNDERHILL, B. M. (1920). "Parasites and Parasitosis of the Domestic Animals," pp. 168-169. (The Macmillan Co., New York.)

VEGLIA, F. (1923). "Preliminary Notes on the Life-history of *Oesophagostomum columbianum*," *9th and 10th Reports, Dir. Vet. Educ. and Research*, pp. 811-823. (Dept. Agric., Pretoria.)

VEGLIA, F. (1928). "Oesophagostomiasis in Sheep" (Preliminary Note), *13th and 14th Reports, Dir. Vet. Educ. and Research*, Part II, pp. 755-797. (Dept. Agric., Pretoria.)

VEGLIA, F. (1928). "Si cercano esemplari di *Bilharsia bovis*," *Giornale di Medicina Veterinaria*, Anno. LXXVII, N. 31, 4 Agosto.

VRYBURG, A. (1907). "Bilharzia-Würmer bei Rindern in Sumatra," *Centralbl. f. Bakt., etc.*, 1 *Abt. Originale*, Vol. 43, No. 1, pp. 806-809.

WALKER, G. K. (1906). "A Preliminary Note on 'Gillar,' a Disease affecting Sheep and Goats," *Jl. Trop. Vet. Sc.*, Vol. 1, No. 4, pp. 410-413.

WEINBERG, M., EN SEQUIN, P. (1914). "Recherches biologiques sur l'éosinophilie," *Ann. Inst. Pasteur*, Vol. 28, pp. 1-39.

WOOLRIDGE, G. H. (1923). *Encyclopaedia of Veterinary Medicine, Surgery, and Obstetrics*, Vol. 1, pp. 333-334. (Frowde and Hodder & Stoughton.)

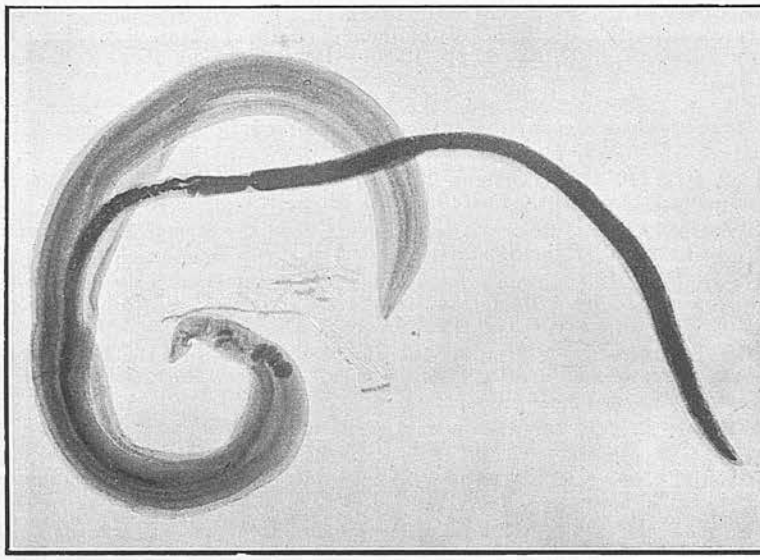


FIG. 1.
Schistosoma mattheei Veglia and Le Roux (1929). The female partly imbedded in the gynaecophorus groove of the male.

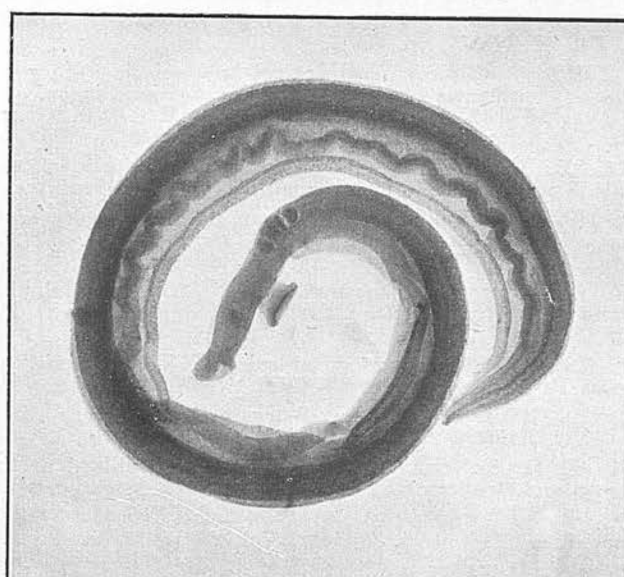


FIG. 2.
A male with prominent ventral sucker. Note the dorsal groove.

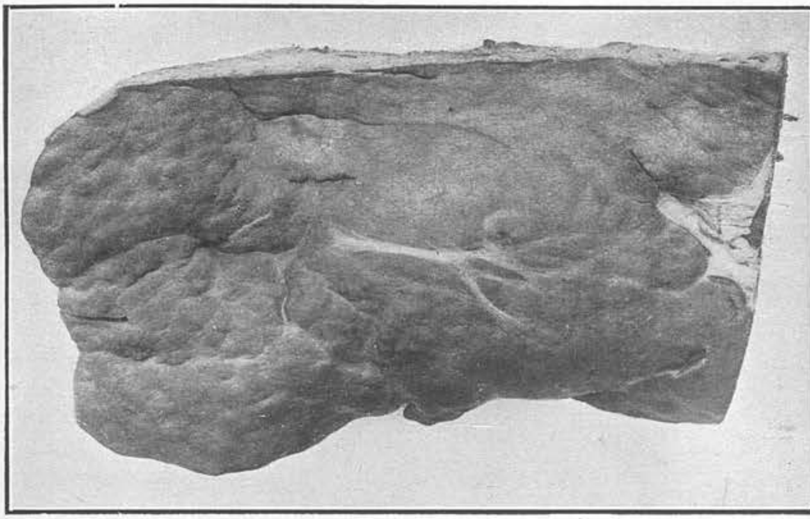


Fig. 3.
The visceral surface of a portion of a hypertrophic cirrhotic liver. Sheep killed.

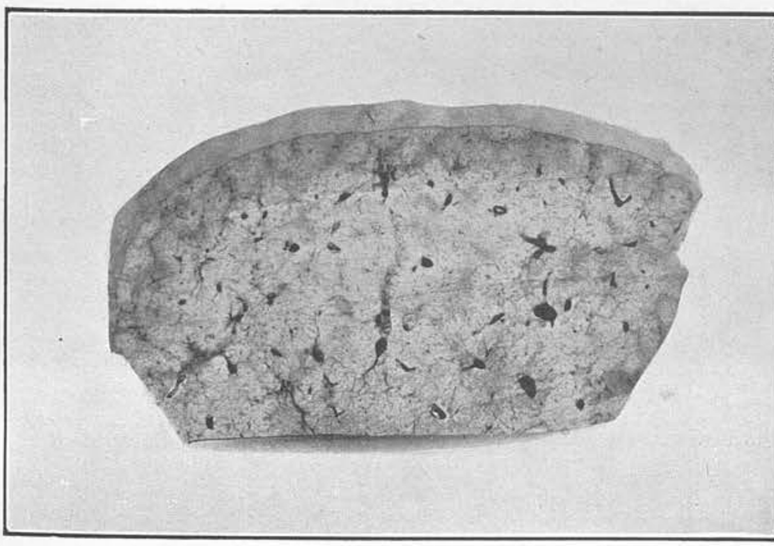


Fig. 4.
Portion of liver (case Fig. 3), showing pigmentation especially towards the periphery.

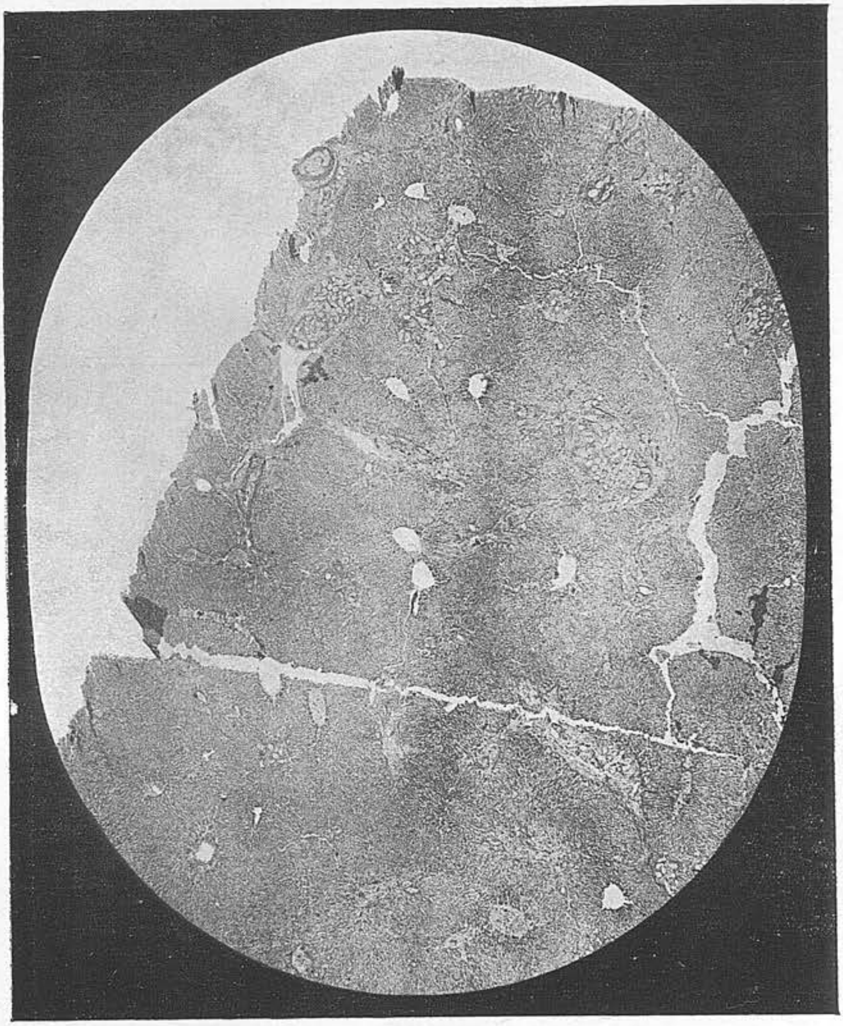


Fig. 5.
Encapsulated groups of eggs arrested in the liver. Sheep died.
Magn. 14 ×.

FIG. 6.
Two eggs and pigment in a hepatic branch of the portal vein. Sheep killed. Magn. 125 ×. Spec. No. 8324.

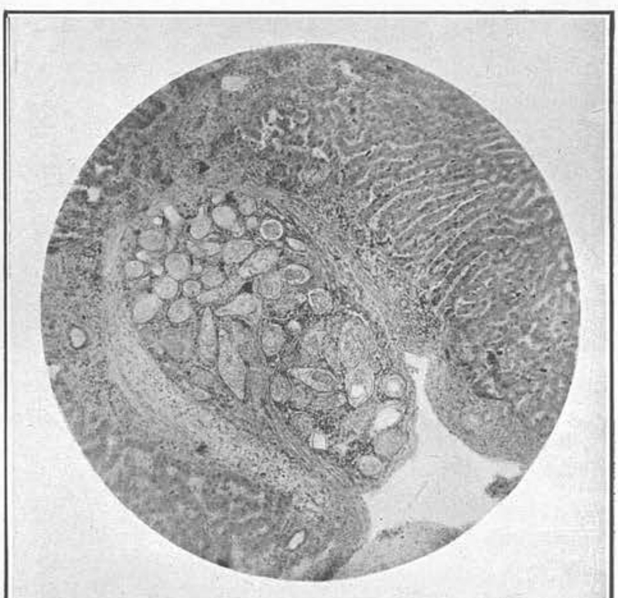


FIG. 7.
Eggs arrested in a branch of the portal vein. Sheep died. Magn. 60 ×. From Fig. 5. Spec. No. 8068.

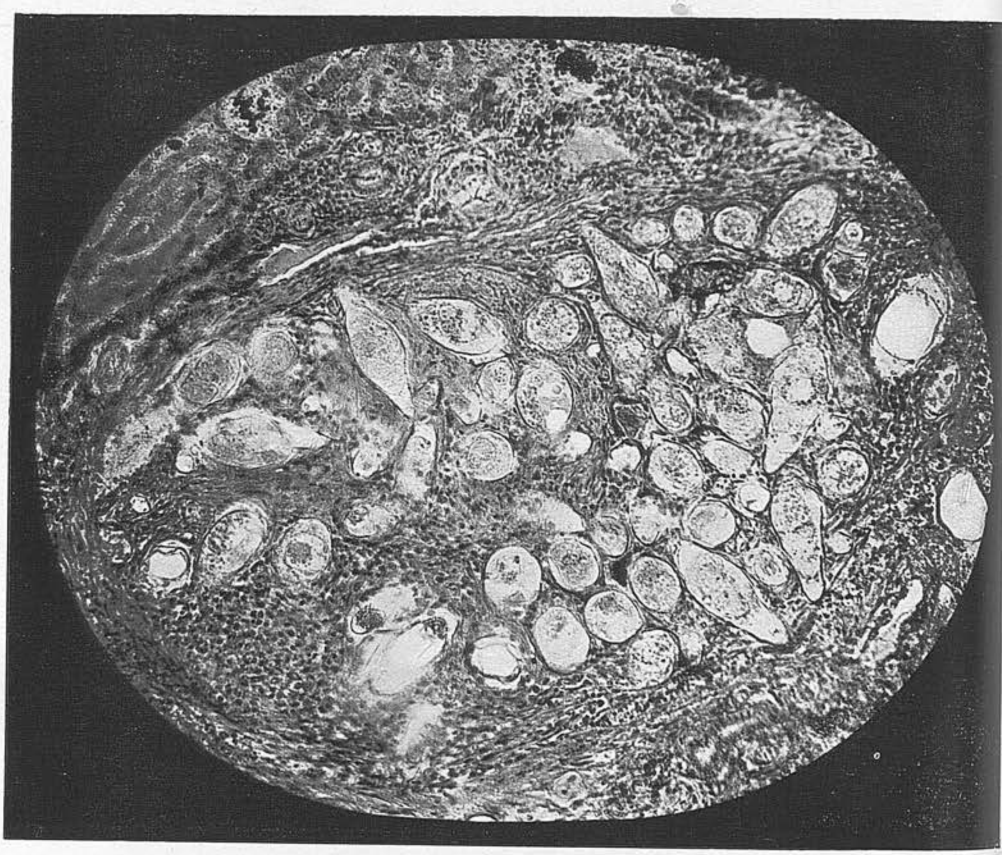


Fig. 8.
Encapsulated group of eggs in the periportal zone. Liver. Sheep died.
Magn. 135 ×. From Fig. 5. Spec. No. 8068.

FIG. 9.
Hepatic branch of the portal vein, showing almost complete occlusion from an organized thrombus. Sheep killed. Magn. 70 ×. Spec. No. 8775.

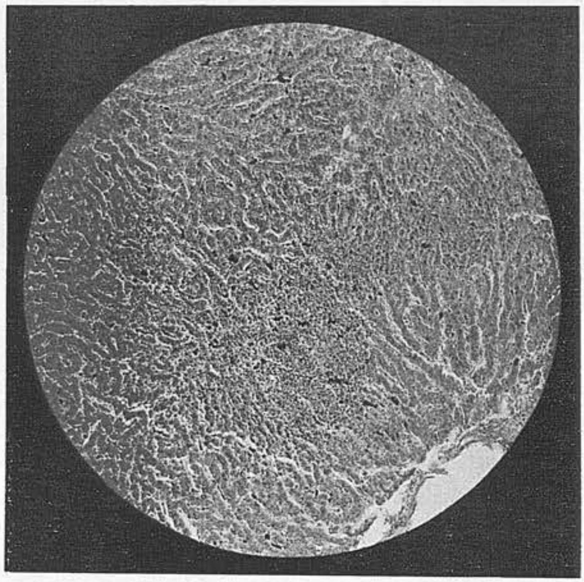


Fig. 10.
Degenerative changes and pigmentation. Liver. Sheep killed.
Magn. 75 ×.

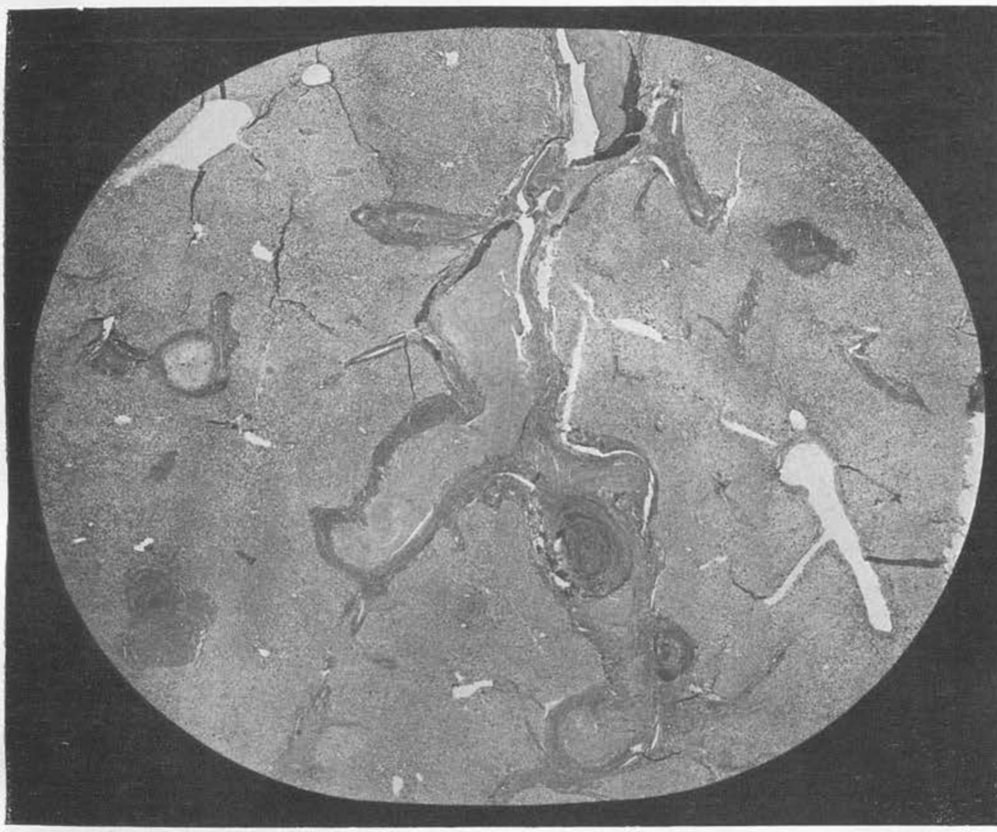


Fig. 11.
Dead schistosomes arrested in the branches of the portal vein. Note the heavy pigmentation. Sheep killed after treatment with tartar emetic. Magn. 14 ×. Spec. No. 8068.

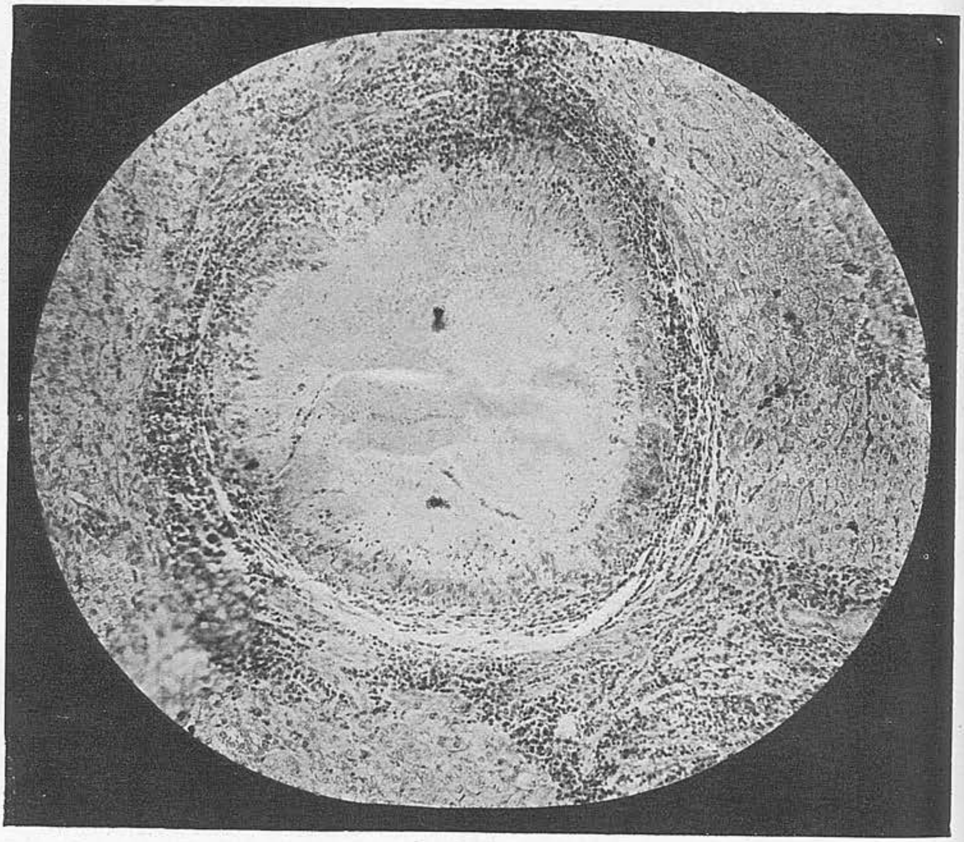


Fig. 12.

Dead male arrested in a branch of the portal vein in the liver. Note cellular accumulation around the parasite. From a sheep treated with Antimony Potassium Tartrate. Magn. 135 ×. Spec. No. 8068.

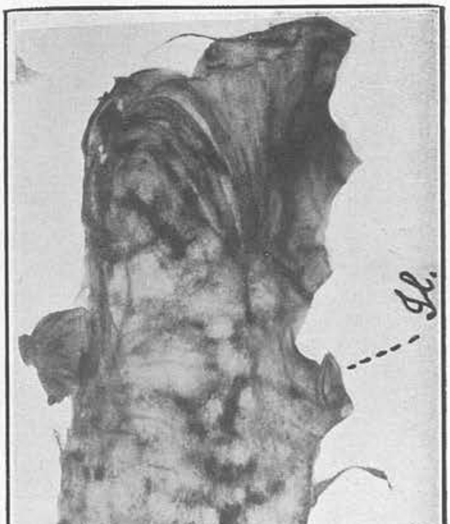


FIG. 13.

FIG. 14.

FIG. 13.—The distal portion of the caecum showing heavy deposition (dark zones) of eggs in its wall. Sheep killed Magn. ½ ×. Incised along the lesser curvature.

FIG. 14.—A proximal portion of the caecum, same case as Fig. 13.

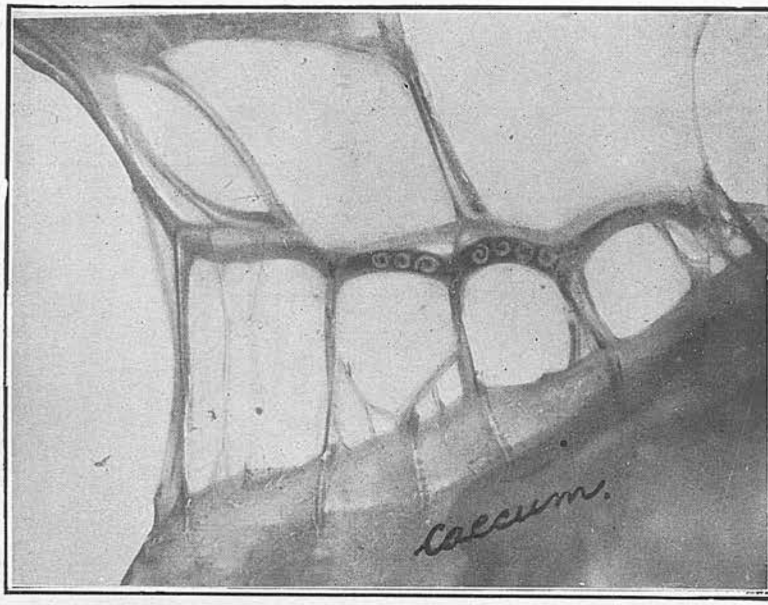


FIG. 15.
Schistosomes in pairs in the veins draining the caecum and the ileum. Sheep killed.

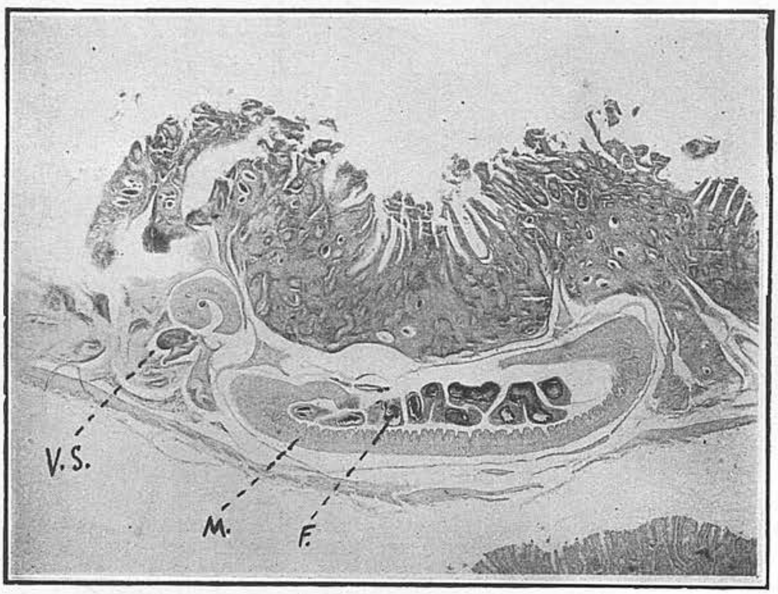


FIG. 16.
Schistosomes in submucosa of small intestine. Pseudo-tubercles in the mucosa propria. Note the ventral sucker (V.S.) of the male. Sheep killed. Magn. 17 ×.

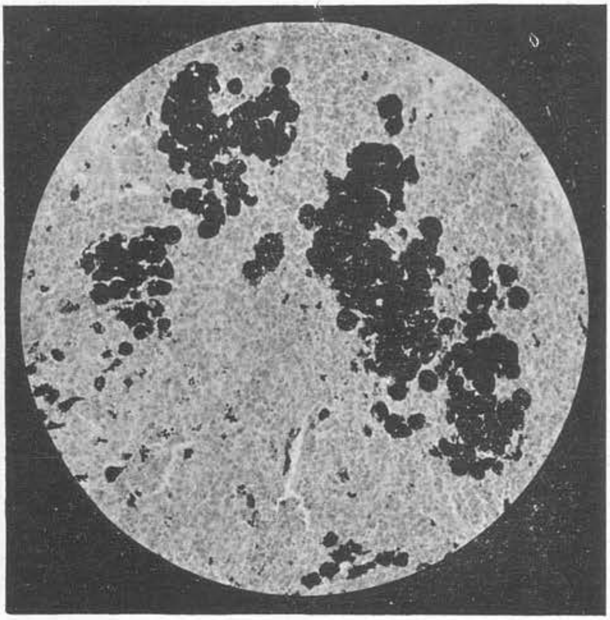


Fig. 17.
Pigmentation of a hepatic lymph gland. Sheep killed. Magn. 135 ×.
Spec. No. 8058.

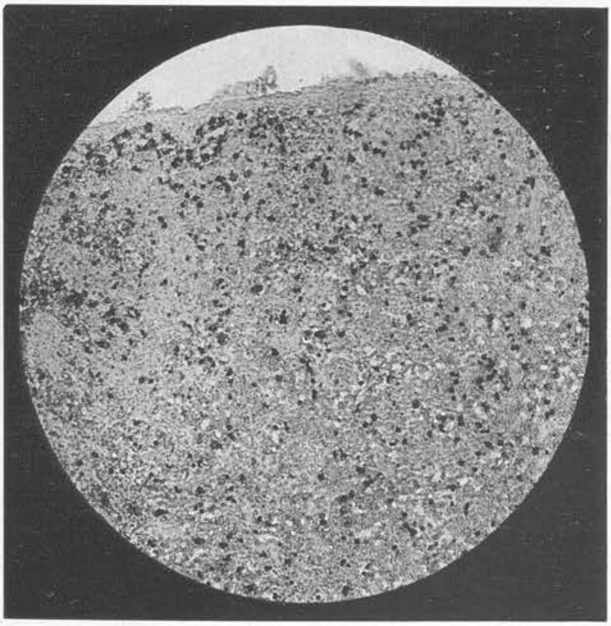


Fig. 17a.
Pigmentation of a hepatic lymph gland. Sheep killed. Magn. 75 ×.

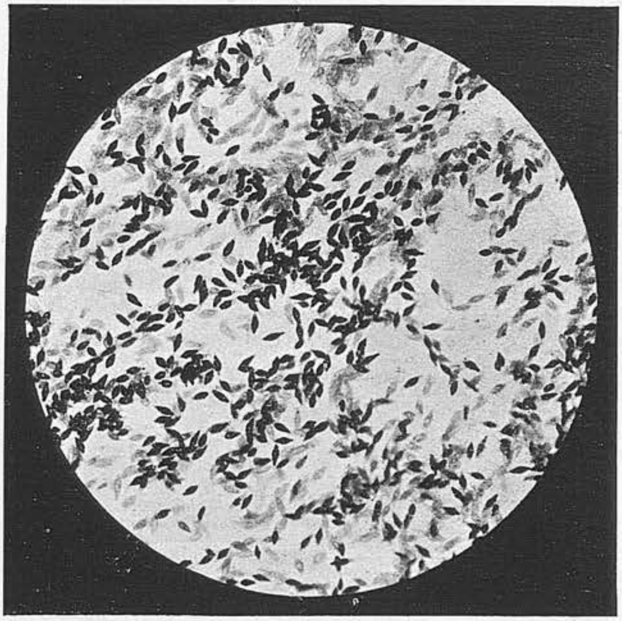


FIG. 18.
Eggs in the mucosa of the small intestine. Sheep killed. Magn. 20 ×.

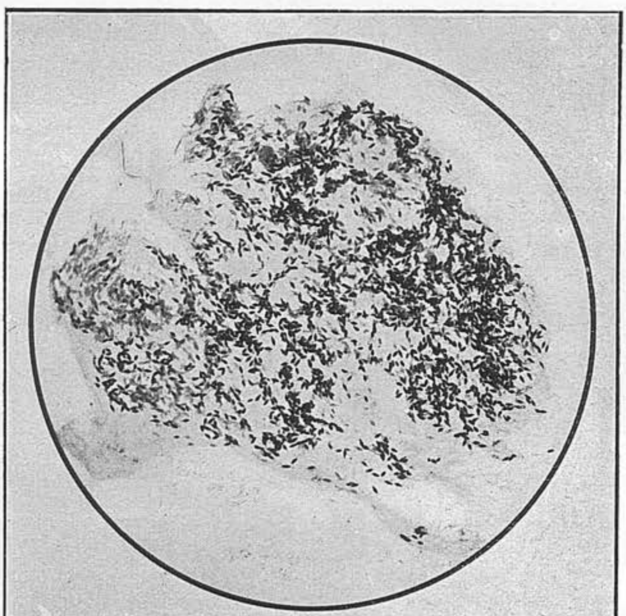


FIG. 19.
Eggs in a piece of mucosa from the caecum. Sheep killed. Magn. 8 ×.

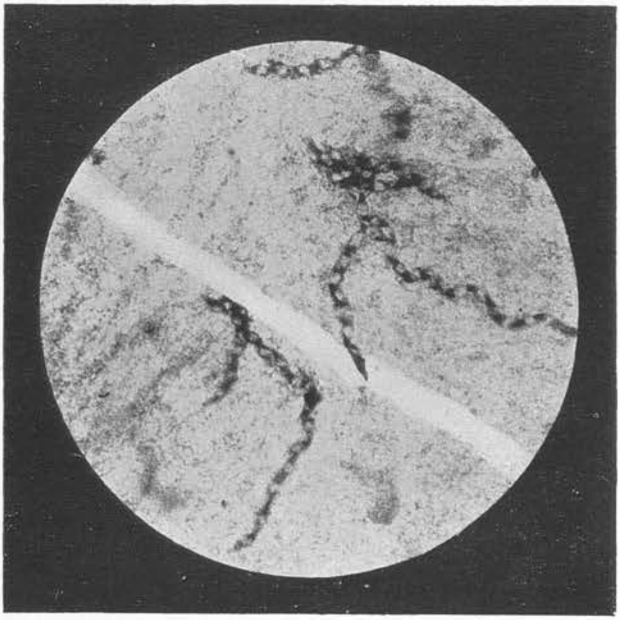


FIG. 20.
Eggs lying in the venules of the small intestines. Guinea-pig, artificially infected with *S. mattheei*. Magn. 35 ×.

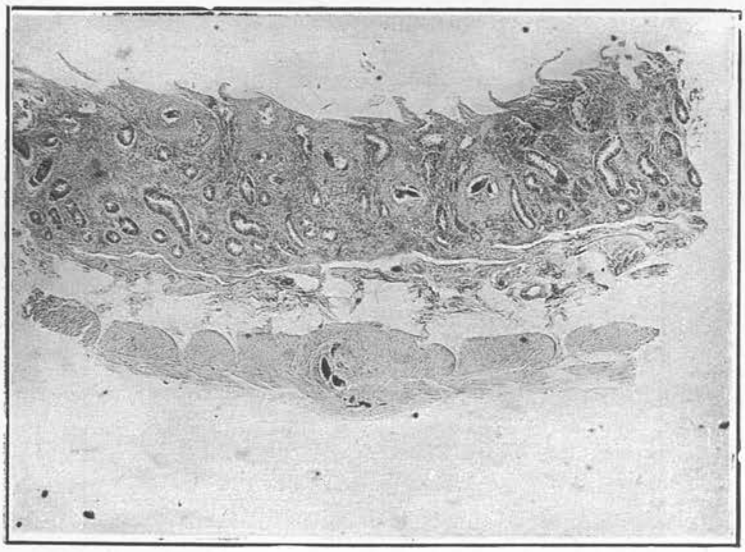


FIG. 21.
Small intestine showing pseudo-tubercles in the mucosa propria, and the muscular layers. Sheep died. Magn. 26 ×.

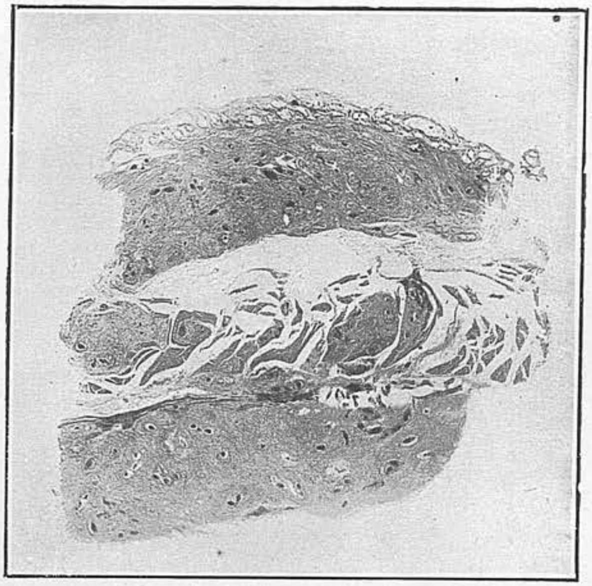


FIG. 22.
Caecum showing pseudo-tubercles in the fibrosed submucosa and muscular layers. Sheep died. Magn. 15 ×.

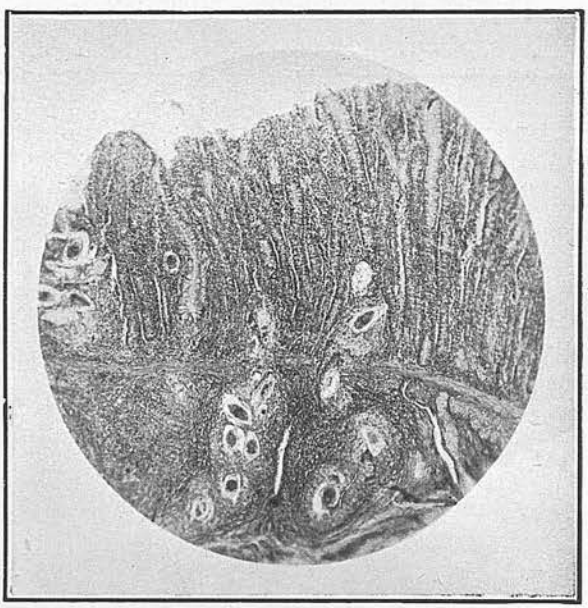


FIG. 23.
Small intestine showing pseudo-tubercles in submucosa and eggs migrating through the muscularis mucosa into the mucosa propria. Sheep killed. Magn. 40 ×. Spec. No. 8323.

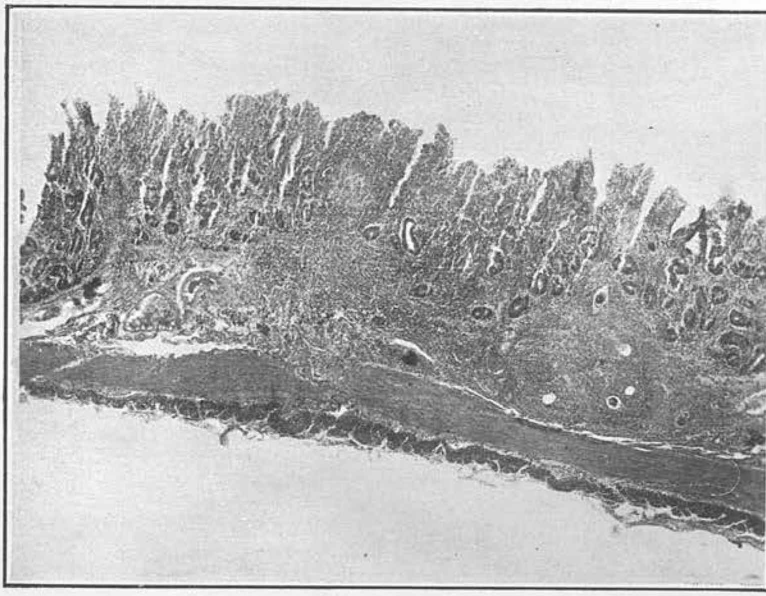


FIG. 24.

Wall of caecum showing pseudo-tubercles in submucosa and mucosa propria. The muscularis mucosa is totally destroyed. Note cellular infiltration of the mucosa propria. Sheep died. Magn. 23 ×. Spec. No. 7887.

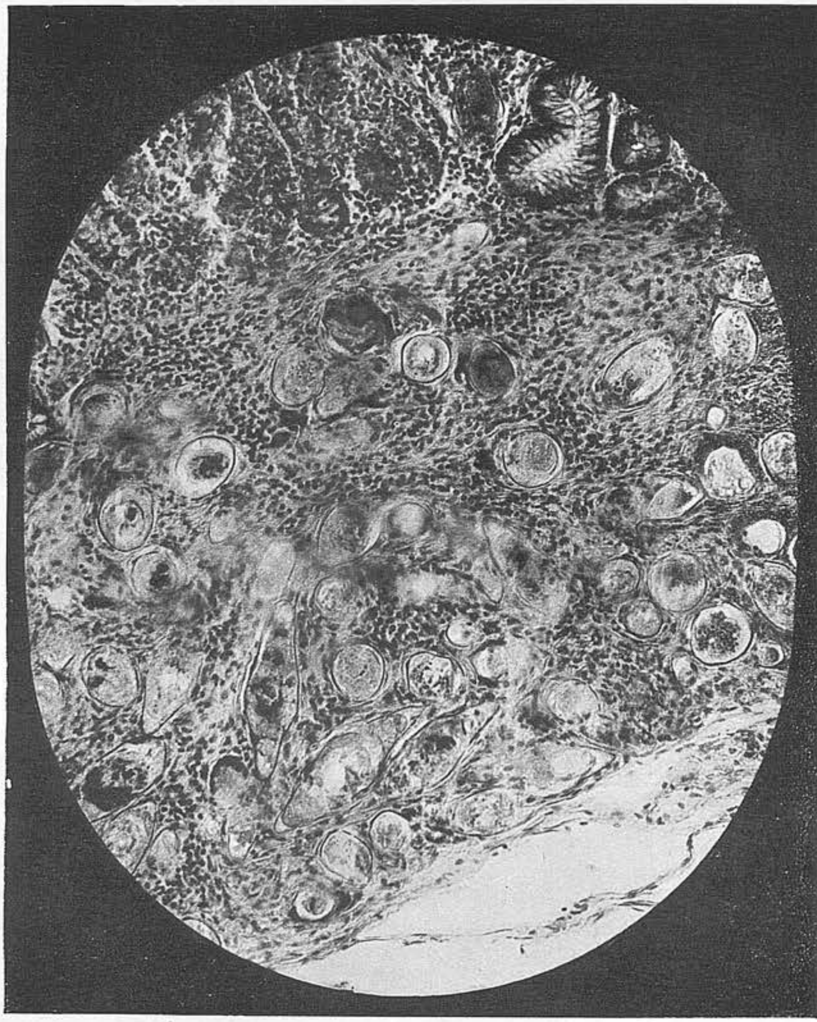


FIG. 25.
Eggs deposited in the submucosa of the caecum. Sheep killed. Magn. 135 ×.
Spec. No. 1862.

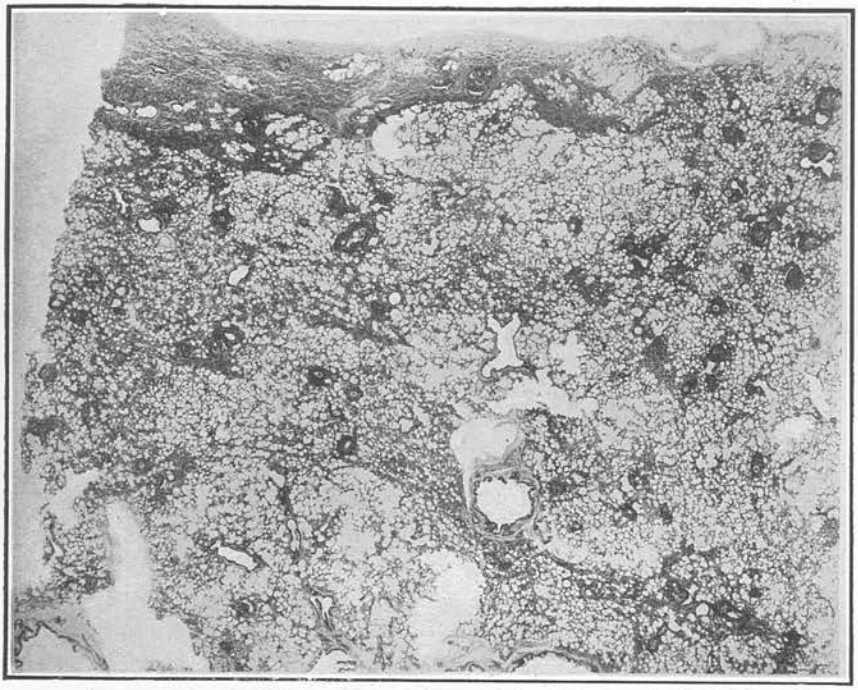


Fig. 26.
Pleura thickened, and numerous pseudo-tubercles. Lung. Sheep killed. Magn. 15 ×. Spec. No. 7783.

Fig. 27.
Developing pseudo-tubercles. Lung. Sheep killed. Magn. 135 ×. Spec. No. 7783.

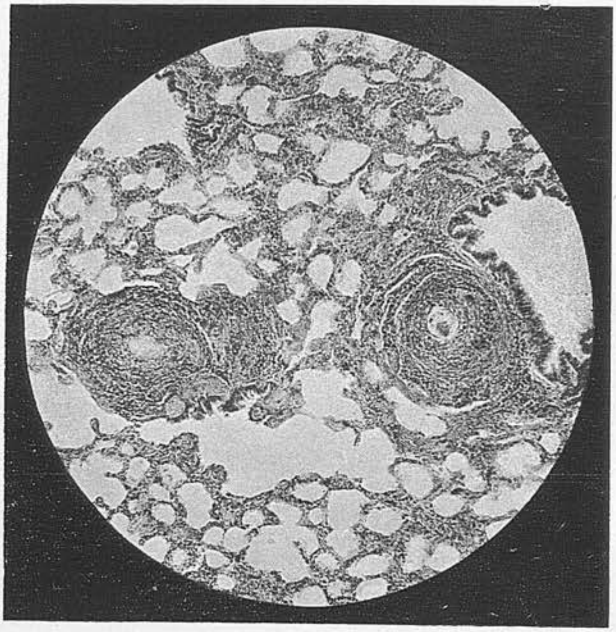


FIG. 28.
Pseudo-tubercles next to a bronchiole. Sheep killed. Magn. 135 ×.
Spec. No. 7783.

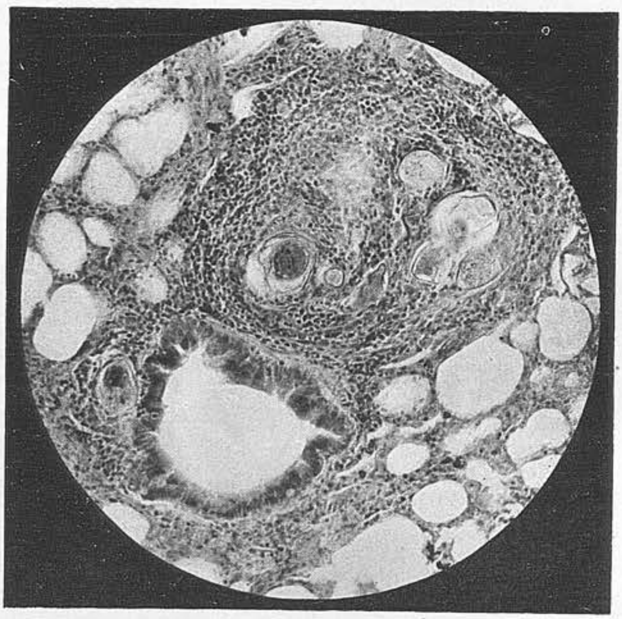


FIG. 29.
Pseudo-tubercles next to bronchiole. Sheep killed. Magn. 75 ×.
Spec. No. 7783.

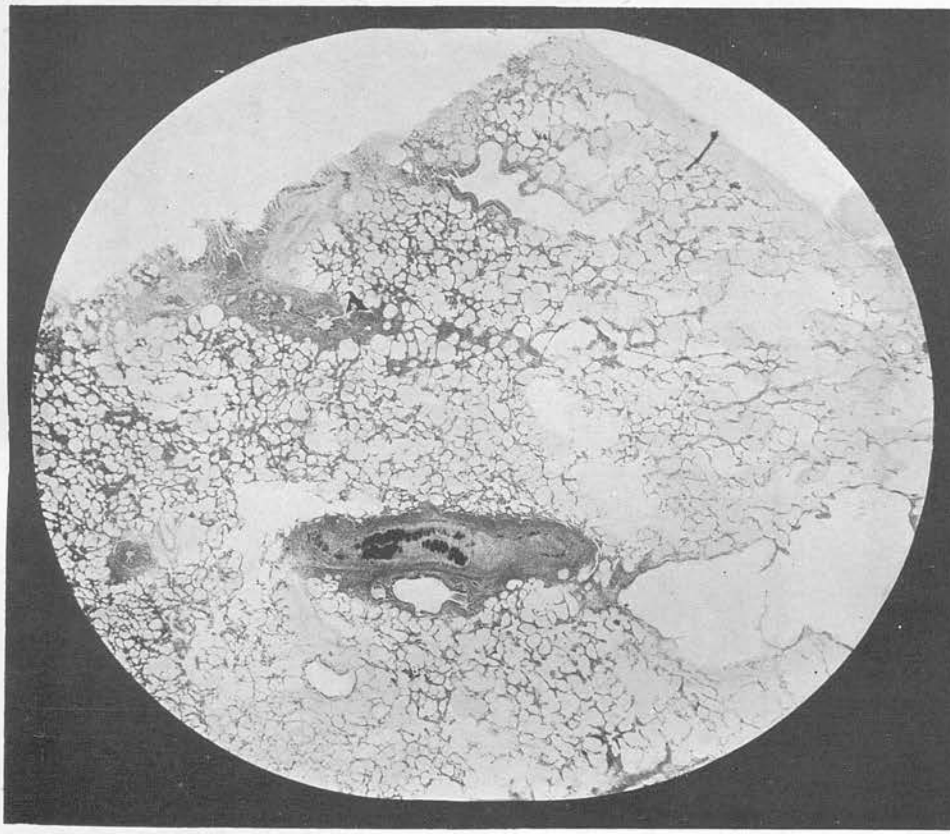


FIG. 30.

A male schistosome arrested in a pulmonary artery. Note the almost complete absence of pseudo-tubercles from this section. Sheep treated with tartar emetic and killed. Magn. 14 ×. Spec. No. 8008.

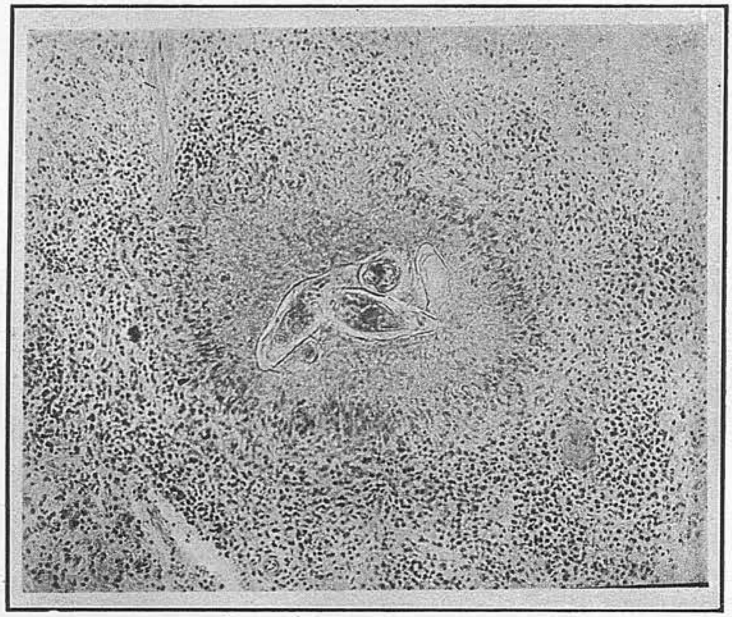


Fig. 31.
Developing pseudo-tubercle in a mesenteric lymphatic gland. Sheep killed. Magn. 120 ×. Spec. No. 8325.

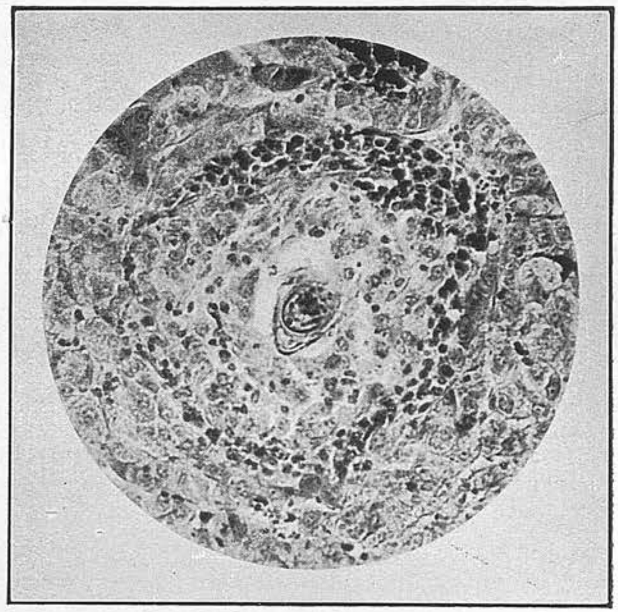


Fig. 32.
Early stage in the development of a pseudo-tubercle. Liver. Sheep killed after experiment via the skin with cercariae of *S. mattheei* from *Physopsis africana* var. *globosa*. Spec. No. 8363.

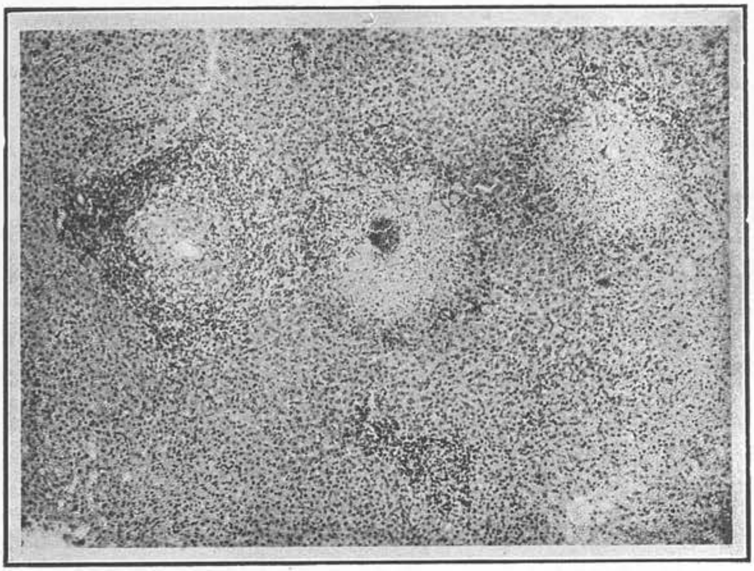


FIG. 33.
Developing pseudo-tubercles. Liver of a guinea-pig experimentally infected with cercariae of *S. mattheei*, obtained from *Physopsis africana* var. *globosa*. Magn. 70 ×. Spec. No. 8624.

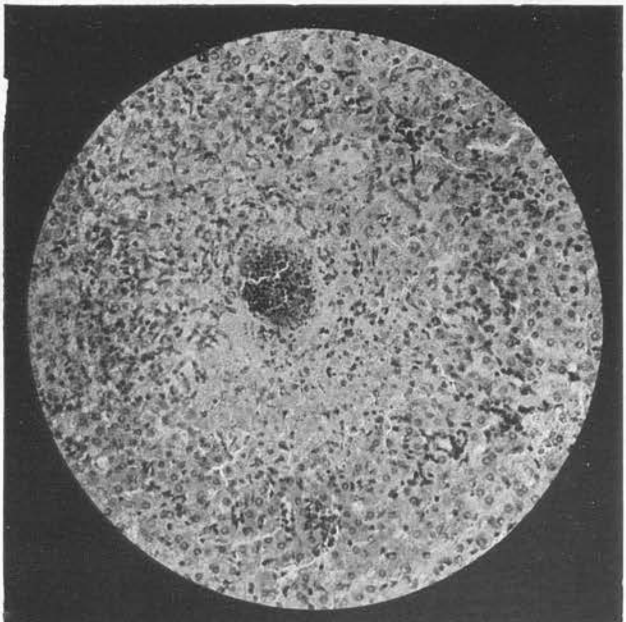


FIG. 34.
Centre pseudo-tubercle from Fig. 33. Magn. 135 ×. Spec. No. 8024.

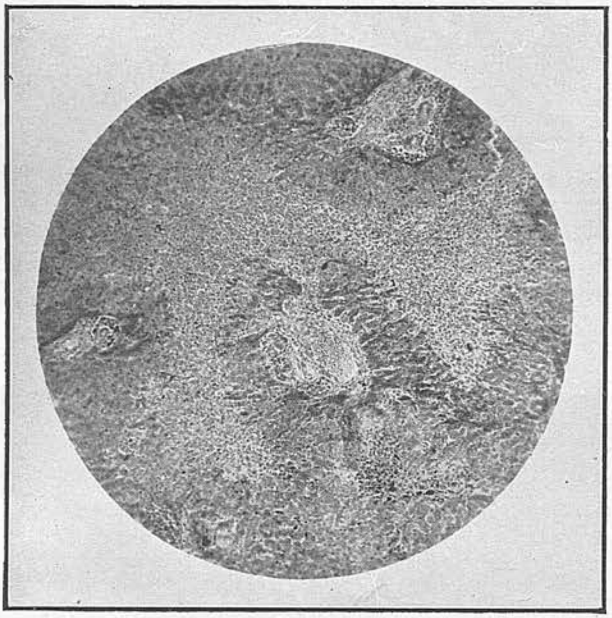


FIG. 35.
Degenerative changes of the liver cells at the centre of the lobule. Cells around the portal tracts not involved to the same extent. Magn. 60 ×.

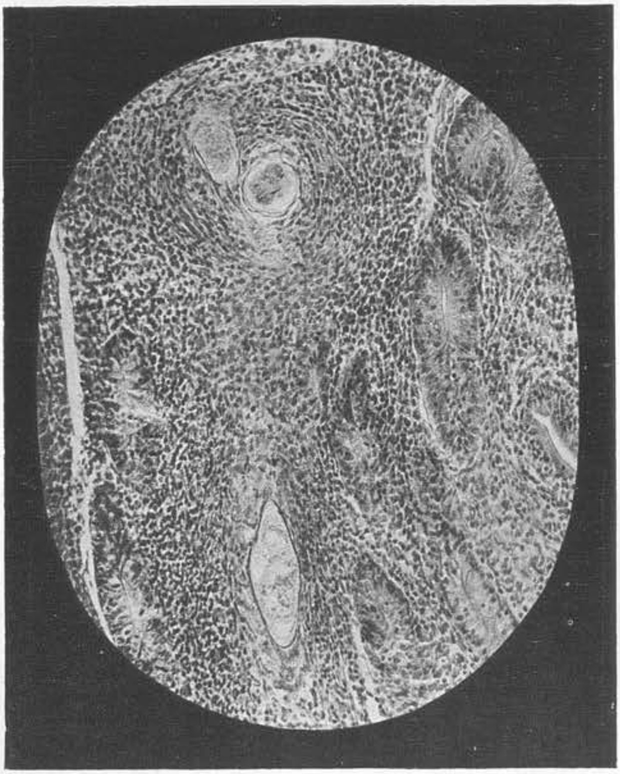


FIG. 36.

Pseudo-tubercle in the mucosa propria and an egg migrating through the tissues. Caecum. Sheep killed. Magn. 135 ×. Spec. No. 8058.

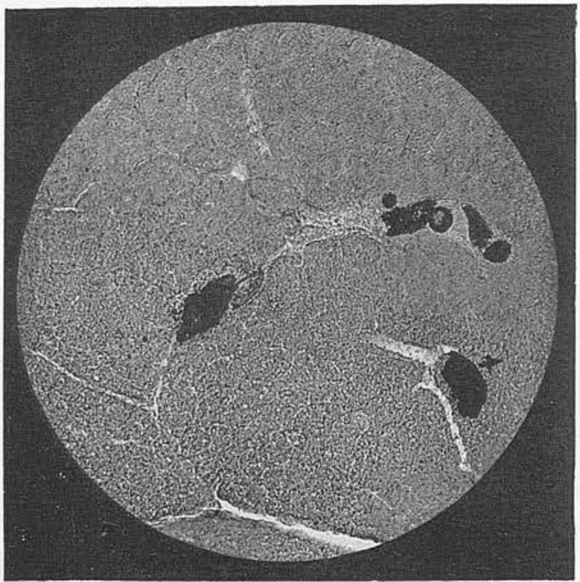


FIG. 37.
Calcified eggs in a pancreas showing a portion degenerated. Sheep killed. Magn. 75 ×.

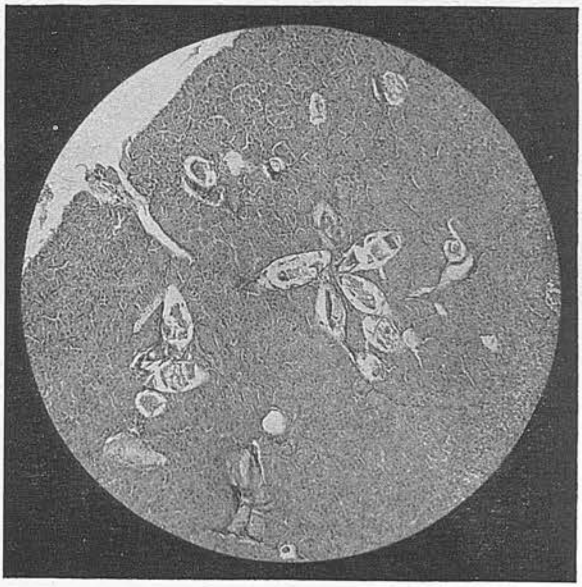


FIG. 38.
Eggs in a lobule of the pancreas. No cellular infiltration is evident. Sheep killed. Magn. 75 ×.

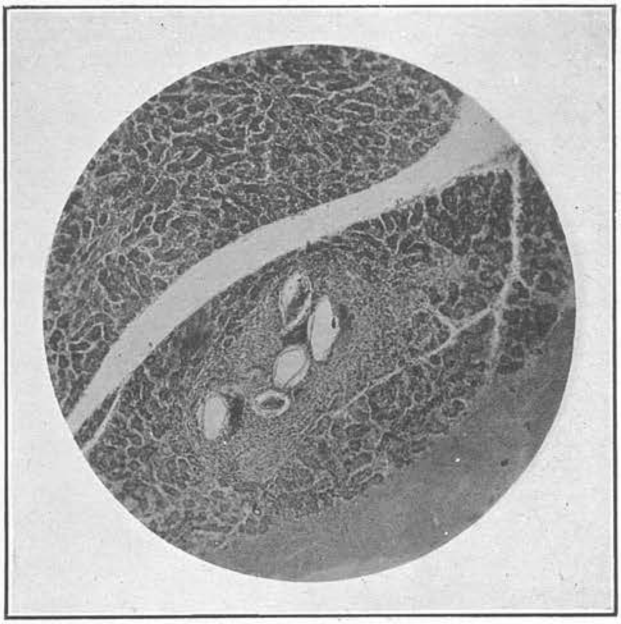


FIG. 39.
Pseudo-tubercle pancreas. Sheep killed. Magn. 60 ×.

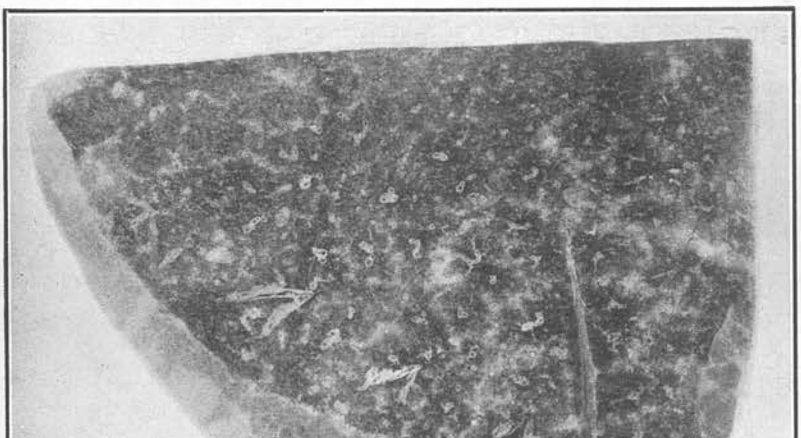


FIG. 40.
Posterior ventral portion of the left lung showing pigmentation. Note the heavy deposition of pigment around the branches of the pulmonary artery. Lobules along the posterior ventral border show hardly any pigmentation. Sheep killed.

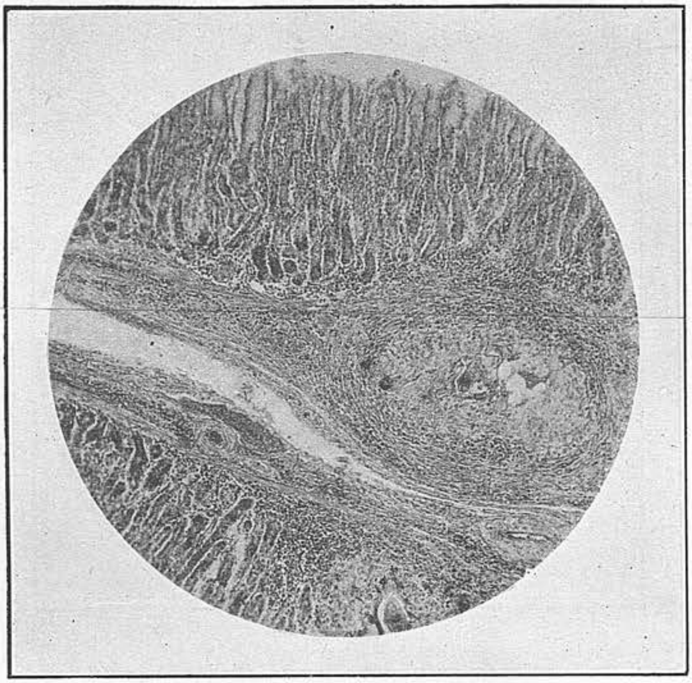


FIG. 41.
Pseudo-tubercle in fold of abomasum. Sheep killed. Magn. 60 ×.

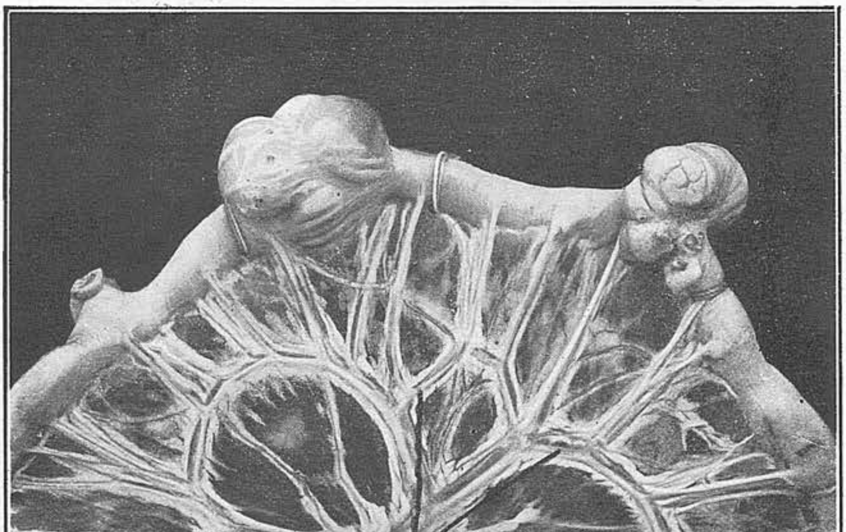


FIG. 42.
Small intestine showing diverticula and calcareous nodules and schistosomes (S) in the veins. Sheep killed. Magn. Natural size.

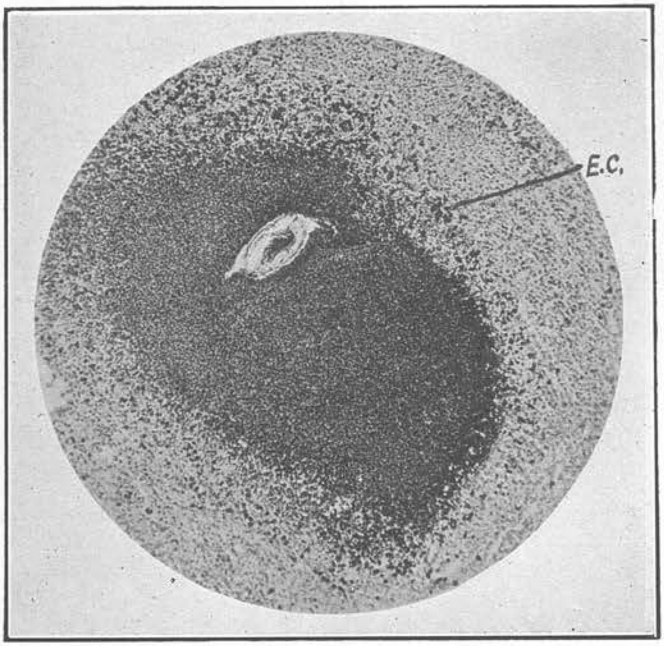


FIG. 43.
Oesophagostomum columbianum nodule, showing the larva, in section, surrounded by leucocytes especially eosinophiles and endothelial cells (E.C.) containing a brownish pigment. Sheep killed. Magn. 70 ×.

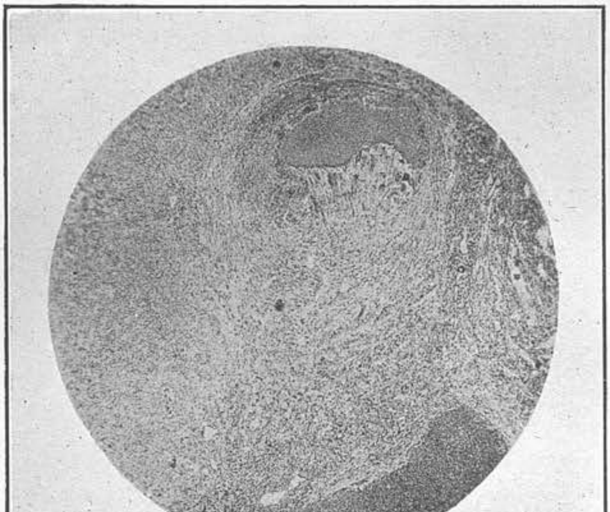


FIG. 44.
Oesophagostomum columbianum nodules, showing fibrous tissue formation stimulated by the larva wandering in the liver. Magn. 35 ×. This field was close to Fig. 43, and indicates a former habitat of the larva. Magn. 35 ×.

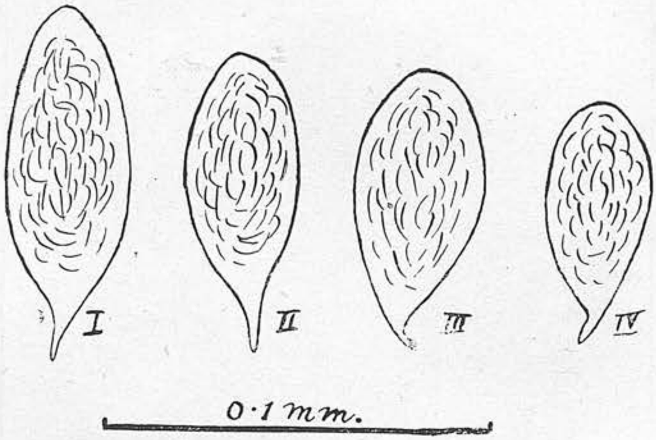


Fig. 45.
Eggs from the uterus of a female which had been subjected to tartar emetic treatment *in vitro*.

Fig. 46.
Kidney with the perirenal fat showing extensive fat necrosis. Sheep infected with *S. mattheei*.

Article No.2.

15th Annual Report of the Director of Veterinary Services, Union of South Africa. October, 1929.

Notes on the Life-Cycle of *Schistosoma mattheei* and Observations on the Control and Eradication of Schistosomiasis in Man and Animals.

By P. L. LE ROUX, B.Sc. (Edin.), M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

INTRODUCTION.

THE life-cycles of the three common human schistosomes have been extensively investigated within the last fifteen years. Miyairi and Suzuki (1913) traced the development of *S. japonicum* in a small amnicolid snail. Leiper and Atkinson (1915) reared the cercaria of *S. japonicum* in the snail *Blanfordia nosophora* (Robson). Leiper returned to Egypt and within a few months proved that *S. haematobium* is transmitted by *Bulinus contortus* (Michand), *B. dybowskii* Fisher, and *B. innesi* (Pallary), and that *S. mansoni* has *Planorbis boissyi* Potiez and Michand, as its invertebrate host. It is, perhaps, remarkable that Leiper did not trace the invertebrate host of *S. bovis* (Sonsino) which parasitizes domesticated ruminants in that area.

Other schistosomes which have been recorded from man are: *S. faradjei* Walkiers, 1928, from the Belgian Congo, *S. incognitum* Chandler, 1928, from Bengal in India, and *S. spindalis* var. *africana* Porter, 1926. The first two mentioned were founded on the size and shape of their eggs, which are passed in the faeces. The adults are unknown. The species, *S. spindalis* var. *africana* (syn. *S. spindalis* of Cawston, 1928), was reared in mice, infected with cercariae from *B. tropicus* and *P. pfeifferi*. The snails were infected with miracidia hatched from schistosome eggs, obtained from the urine of two humans in South Africa. The morphology of this species is imperfectly known. From the data available, it is evident that these three species should be regarded as *species inquirendae* until the adults are found.

The size and the shape of the eggs within a species may show considerable variation, as will be evident from the figures (Plate I, Figs. I to VIII and 1 to 7). If the eggs alone are to be considered for the diagnosis of a species, it is evident that this Pretorian was infected with at least four or five different species of schistosomes. There are eggs present reminding one of those of *S. haematobium*, *S. incognitum*, *S. bomfordi*, *S. mattheei*, and *S. spindalis*. It would undoubtedly be most unusual to have one human infected with all these species. The three last mentioned inhabit the radicles of the portal vein in domestic stock and can therefore hardly be expected to prefer the urino-genital tract when localized in man.

The schistosomes recorded from domestic stock are:—

(1) *S. bovis* (Sonsino) Khalil 1924, from cattle and sheep in Africa and Europe (Italy, Sardinia), India, and from cattle in Cochin China.
(2) *S. bomfordi* Montgomery 1906, from cattle in India and Southern France.
(3) *S. spindalis* Montgomery 1906, from cattle, goats, and the water buffaloes in India and cattle in Sumatra.
(4) *S. indicum* Montgomery 1906, from equines and sheep in India.
(5) *S. japonicum* Katsurada 1904, from man and various mammals (horse, ox, sheep, cat, dog, etc.) in the Far East.
(6) *S. turkestanicum* Skrjabin 1913), from cattle in Russian Turkestan.
(7) *S. mattheei* Veglia and Le Roux 1929, from sheep and cattle in the Cape Province.

The invertebrate hosts of some of the schistosomes have been determined and may be briefly considered.

The snails responsible for the perpetuation of *S. haematobium* and *S. mansoni* in Egypt have been considered above. In South Africa the intermediate host of *S. haematobium* was first demonstrated by Becker (1916) to be *Physopsis africana*. His findings have since been verified by Cawston, Faust, and Porter. Porter (1920) also incriminates *Lymnaea natalensis* Krauss, but judging from the prevalence of this snail throughout a large area of the Union and the localization of *S. haematobium* only in areas inhabited by *Physopsis*, it would appear that *L. natalensis* need not be considered as a vector in the spread of schistosomiasis. Porter (1925) names *Physopsis conicum* as a host of *S. haematobium*. In Portugal the host is *Planorbis dufourii* Graells, according to Franca (1922) and Bettencourt and Borges (1922); in Nyasaland it is, according to Dye (quoted by Christopherson, 1923), a species of *Physopsis*, allied to *P. africana* var. *globosa* (Morelet); in Sierra Leone, Blacklock and Thompson (1924) obtained, from *P. africana* var. *globosa*, cercariae which were reared to maturity in animals and proved on examination to be the adults of *S. haematobium;* in Tanganyika Territory the snail, *Physopsis nasutu* v. Martens, is held responsible by Corson, 1927; Ingram (1924) suspects *P. globosa* as the carrier on the Gold Coast; in Cyprus, Leiper (1928) found *B. contortus* prevalent in the endemic area. In Lourenco Marques it is *P. africana* var. *globosa*, according to Cawston (1925).

Schistosoma mansoni is evidently by no means common in South Africa. Porter (1920) records that the South African fresh-water snails, *Physopsis africana*, *Bulinus tropicus* (Krauss), and *Planorbis pfeifferi* Krauss, can serve as intermediate hosts of this blood-fluke. Faust (1920) recognizes the cercariae of *P. mansoni* amongst cercariae from *P. africana* from Natal. In Venezuela, according to Iturbe and Gonzalez (1917), the intestinal schistosomiasis is propagated by *Planorbis guadelupensis* Sowerly. These authors also claim to have artificially infected *Pomacea luteostoma* and *Planorbis cultratus*. In Brazil the snails *P. centimetralis* Ad. Lutz and *P. olivaceus* Spix, are the hosts incriminated by Lutz (1919); in the West Indies it is *P. antiguensis* Gould, according to Jones (1923); while in Dutch Guinea Khalil (1921) found the snail *P. olivaceus* infected; in Madagascar, Haslé (1928) found *Planorbis madagascariensis* infected; Marin (1928) records that Hoffman had experimentally shown *P. guadelupensis* to be the host in Porto Rico.

Schistosoma japonicum (Katsurada) was found by Leiper and Atkinson (1915) to be transmitted by *Blanfordia nosophora* (Robson) (syn. *Oncomelania nosophora; Katayama nosophora; Hypsobia nosophora*). Cort (1919) confirmed the findings of Leiper and Atkinson when he infected rats with cercariae from this snail. In Formosa the host is *B. formosana* Pilsbry and Hirase. In the Yangtze Valley, China, the host was found by Melency and Faust (1923) to be *Hemibia hupensis* (Gredler) (syn. *Melania hupensis; Oncomelania hupensis; Melanis schmackeri*).

Schistosoma spindalis Montgomery, 1906, was found by Liston and Soparkar (1918) to be naturally transmitted by *Planorbis exustus* Deshayes at Bombay. Fairley and Jasudasin (1927) infected water buffaloes experimentally.

Schistosoma spindalis var. *africana* Porter, 1926, is, according to its discoverer, transmitted by *Planorbis pfeifferi* and *Bulinus tropicus*. Bequaert (1928) regards these experiments of Porter as inconclusive.

The life-cycles of all the other animal schistosomes except that of *S. mattheei* are still to be determined. It would surely not be unusual to find that *Bulinus contortus* transmits the so-called *S. bovis* of Egypt, Sardinia, and Sicily.

S. bovis (Sonsino) Khalil is, according to Cawston (1928), transmitted by *Physopsis africana* in Natal. Faust (1921) described, from *P. africana* in Natal, the *Cercaria octadena*, which he believes to be the larval stage of *S. bovis*.

There are cases on record (Cawston, 1921, 1922, 1927, and 1928) where spindle-shaped eggs resembling those of *S. bovis* have been observed in the urine of humans in Natal. Leiper (1923), who had the opportunity of examining some of these eggs observed by Cawston, has doubted this possibility because intermediate forms between these eggs and eggs typical of *S. haematobium* were observed. Brumpt (1922) expresses himself against such a possibility in the statement: "Cette determination est probablement inexacte, cas de dernier ver ne produit que des lésions intestinales chez le boeuf."

Mahfuz (1927) has in Egypt recovered from the urine of a patient suffering from haematuria and painful micturition eggs believed to be those of *S. bovis*. Cawston (1928) writes: "In Natal, however, one sometimes encountered the eggs of other schistosomes associated with those of *S. haematobium*, and adult species of *S. bovis* have been reared from cercariae obtained from *Physopsis*. whilst *S. spindalis* has been successfully reared in the Transvaal and would seem to occur as a rare parasite of man in Natal." Cawston (1928) writes: "I am not aware that bilharziasis has been demonstrated in any animal in South Africa, except in man." In a letter (quoted by Faust, 1926) dated June 29, 1920, Cawston wrote to Faust as follows: "Dr. R. T. Leiper has no hesitation in diagnosing some adult schistosomes from one of my guinea-pigs as *Schistosoma bovis*, which have not previously been found in South Africa; but I have not yet traced the cow (the usual host) that infected the *Physopsis* used in the experiments. To this Faust (1926) remarks: "In fact, the 'cow,' hypothecated by Dr. Cawston, may not be necessarily involved in the *Schistosoma bovis* life-cycle in Natal; man may possibly serve in this capacity." Blacklock (1925), discussing schistosomiasis in Sierra Leone, asks the questions: "Is *S. bovis* present?" and continues: "The position of *S. bovis* appears to be somewhat uncertain, both geographically and morphologically, and also as regards the vertebrate and mollusc hosts. The present vague conception of what *S. bovis* actually is makes it difficult for workers in endemic areas to incriminate snail hosts, unless adult females containing eggs develop in the experimental animals."

In the discussion of Blacklock's (1925) paper, Prof. Leiper refers to the paucity of intestinal infections in Sierra Leone with *S. haematobium* in marked contrast to the findings of Chesterman in the Congo, where *S. haematobium* occurs mostly in the faeces. In Egypt the vesicle infection predominates, and it was because Harley (1864) found only terminal-spined eggs in the urine of his patients at Port Elizabeth that he named *Distomum capense* to differentiate the South African blood-fluke from that recorded from Egypt, where lateral-spined ova were also common.

Nessmann and Trenz have at Gabon in French West Africa found cases of intestinal schistosomiasis without indications of cystic involvement. The eggs passed in the faeces were terminal-spined and were taken for those of *S. haematobium*. No details as to the morphology of the adult parasite are available. The authors do not give figures or measurements of the eggs observed. Reynard and Leger (1922) have in Central Africa seen cases of rectal schistosomiasis without vesicle implication.

It has by no means been proved at autopsy that *S. haematobium* can ever produce intestinal schistosomiasis without involvement of the urinary bladder. Brumpt (1928) records the infection of a hedgehog with *S. haematobium*. He observes that there was no invasion of the urinary bladder. I have not been able to consult the original communication, but from the review of the article in the *Tropical Diseases Bulletin* it is not evident where he obtained the cercariae utilized for infecting the animal. My attempts to rear supposed *S. haematobium* cercariae to the adult stage in sheep, white rats, and guinea-pigs have failed on four occasions. The cercariae used were mammalian schistosome cercariae obtained from *P. africana* var. *globosa*, collected in areas where urinary schistosomiasis is prevalent.

This failure to infect rats with supposed cercariae of *S. haematobium* has been experienced by Ingram (1924) on the Gold Coast, where he tried to infect rats with cercariae from *Physopsis globosa*, Morelet. The *Physopsis* was submitted to miracidium hatched from eggs passed in the urine. He failed to infect *Isidora forskali*, Ehrn. and *Physa waterloti*, Germain.

Here, too, I feel quite satisfied that many of the reports dealing with the rearing of adults of *S. haematobium* in animals other than monkeys are by no means conclusive. It is perhaps not without significance to note that in the guinea-pig, the rats, and the hedgehog, there was no involvement of the urinary bladder, a phenomenon usually observed with *S. bovis* and *S.* ~~*mattheei*~~ /haematobium, which both produce terminal-spined eggs. *S. bovis* is morphologically, according to Leiper (1923), closely related to *S. haematobium*. This is borne out by Khalil's description of the female of *S. bovis*. *S. mattheei* is distinguished from *S. bovis* in that the female of the former has the vitelline glands limited to the posterior half of her body, while in *S. bovis* and *S. haematobium* they are limited to the posterior quarter of the body. *S. bovis* may therefore be readily mistaken for *S. haematobium*. Further experiments are necessary to prove that cercariae of *S. haematobium* can be reared to the adult stage in the animals claimed to have been infected. To prove this beyond doubt, it would be imperative that the experimental snails be bred in captivity so as to exclude any possible infection with other mammalian blood-flukes.

I do not doubt the possibility of rearing this human blood-fluke in mammals other than monkeys, but evidence is wanting.

In the cases where I subjected sheep and guinea-pigs to supposed *S. haematobium* cercariae, there is evidence that development did proceed up to a certain point. In Glisson's capsule there were areas showing cellular infiltrations similar to those seen in guinea-pigs and sheep infected with *S. mattheei*. The lungs, too, showed foci consisting of cellular accumulations. In the centres of some of these foci appeared an amorphous mass suggesting dead cercariae or young schistosomes. These lesions were observed in sheep autopsied on the fiftieth day after infection through the skin.

"SCHISTOSOMA MATTHEEI" VEGLIA AND LE ROUX 1929.

Since the invertebrate hosts of the human blood-flukes are known, it was expected that one of them must be responsible for the transmission of *S. matthei*.

Dr. Veglia visited the endemic area, but he arrived there to find the rivers and the vleis (marshes) in flood. His search for snails was futile. Shortly after this he left the Government service and the rest of the investigation was entrusted to me. The endemic area was visited, but once more rain and extreme cold weather rendered the search for live snails of the genus *Physopsis* futile. The presence of a few empty shells proved the presence of *Physopsis africana* var. *globosa*. Leaves of *Nympheae stellata* were examined for specimens, but only specimens of *Lymnaea natalensis* were recovered. They proved non-infected with mammalian schistosome cercariae. The farm was next visited in summer, when numerous specimens of *P. africana* var. *globosa* were collected from the under-surface of the leaves of the blue lotus. The first snail that was examined proved to be infected with a mammalian schistosome cercariae. Fifty specimens were examined, and of these forty-five were infected. Only the larger specimens yielded cercariae. Infected snails could be readily picked out owing to the abnormally pale colour of the invaded liver. Snails were collected for experimental work at Onderstepoort, but very few arrived alive at Pretoria. With the cercariae from these snails I infected three rats, four guinea-pigs, and two young lambs. The animals were born and reared on the station, and were therefore free of schistosome infection. The rats and guinea-pigs were killed at varying intervals between the fiftieth and sixtieth days, and in every case there were recovered schistosomes indistinguishable, except for size, from those parasitizing the sheep in the endemic area. The sheep were passing eggs from the fiftieth day after infection. The one animal was killed for autopsy six months later, and was found heavily infected with the identical species from Humansdorp.

THE CERCARIA OF *SCHISTOSOMA MATTHEEI.*

The study of the morphology of the cercariae from *Physopsis africana* var. *globosa* shows that the integument is armed with spines. In this respect it differs from *Cercaria octadena* Faust 1921, that is regarded as the larval stage of *S. bovis*. The flame cells are arranged as described for *S. haematobium*. In preserved specimens the body measures 160μ to 260μ in length by 65μ to 80μ in diameter. The trunk of the tail varies in length between 180μ to 280μ and has a width of 38μ to 42μ. The *furci* measures from 80μ to 120μ. The dimensions of the anterior suckers were 56μ to 80μ by 40μ to 46μ. The cephalic secretory glands numbered four (two pairs are acidophilic, while the remaining pairs are basophilic). In this respect the cercaria resembles *C. octadena*, with which it may be identical except for the presence of the cuticular spines.

Leiper (1915) considers that animal experiment gave the most satisfactory differentiation between the two species *S. haematobium* and *S. mansoni*. This is undoubtedly a more satisfactory and sure means of differentiating between species than the more laborious method of differentiating morphologically. Blacklock (1925), commenting on the identification of schistosome cercariae, writes: "It would be a great advantage to discover some quicker way of proving a snail to be a carrier of *S. haematobium* infection than the method of animal experiment, and it is possible that some such method may yet be found; owing to the morphological resemblances of *Schistosome* cercariae, it does not seem that diagnosis by this stage is reliable. . . ." "Attraction of miracidia to snails does not appear accurate, nor does the subsequent recovery from the snail of 'typical *S. haematobium* cercariae' until we know what does indeed constitute such."

The development of the miracidium to a cercaria in the digestive gland of the snail is not unlike that described for other schistosomes (the miracidium $\rightarrow$ sporocyst $\rightarrow$ daughter sporocysts $\rightarrow$ cercariae which penetrate the skin or buccal mucosa of the definitive host).

While experimenting with fresh-water snails and the newly hatched miracidia, it was found that the latter are attracted by *P. africana* var. *globosa*, *Lymnaea natalensis*, and a species of *Bulinus*, but not in the least by *Planorbis pfeifferi*. The cercariae would attach to the foot, head, and the antennae of the three first-mentioned snails, but were never observed to penetrate into these parts, even after having been attached for fully quarter of an hour. The normal route of infection seems to be via the respiratory tract.

If a snail is watched in the presence of a few attacking miracidia, it will be observed that those drawn into the pulmonary cavity with the inrushing water are hardly ever returned. By counting the cercariae in a dish of water and then watching the snail, which has been dropped in, it was found that all the miracidia disappeared into the pulmonary cavity. When different snails were simultaneously added, the miracidia seemed to show a slight preference for *Physopsis* and a decided preference for the larger snails. Hitherto it has only been possible to rear the miracidia to the cercarial stage in *Physopsis*, and this was only successful after repeated attempts. Most of the snails would die within a week after subjection to infection. At first the controls could not be kept alive for more than four weeks. *Physopsis* is not easily kept alive under the conditions here. By continually adding leaves of the blue lotus they seem to do much better.

The other snails (*Lymnaea natalensis*, *Bulinus* sp., and *Planorbis pfeifferi*) bred well in captivity.

BIONOMICS OF *P. AFRICANA* VAR. *GLOBOSA* IN THE ENDEMIC AREA.

Blacklock and Thompson (1924) remark that *Physopsis c.f. globosa* Morelet was found " in waters which lay or ran slowly on a muddy bottom, where weeds or grass grew in the water, and under high or low shade." At Humansdorp this species was found in localities where the river had overflowed and had formed pools off its main course or where the main course had been dammed up. I can confirm the observations of the two workers, quoted above, except that as regards shade the opposite was the case with the carrier of *S. mattheei*. Local climatic conditions may account for this variation. Humansdorp is situated about fifty miles south-west of Port Elizabeth and the average temperature is undoubtedly below that of Sierra Leone. At Humansdorp the snails were most numerous on the under-surface of the leaves of the blue lotus growing in direct sunlight and where the bottom of the pool was covered with decomposing vegetable matter mixed with mud. The snails seem to favour those pools where the depth of the water varies between three and four feet.

CAN *SCHISTOSOMA MATTHEEI* INFECT MAN?

Judging from the fact that the pool responsible for the infection of the sheep is used by man and beast alike, it is only natural to assume that if man could be infected, the human beings on the farm should have been. Both urine and faeces were examined with negative results. The infected pool is about two miles long, but only about twenty yards wide and, except at the one end, very deep.

On my second visit there I suggested bathing in that portion where there were no snails, but the young fellows assured me that my skin would " burn " for hours if I did. This, they informed me, was especially the case towards the end of summer. I next tried to get them to have all the lotus leaves removed so that I could test the effect of copper sulphate on the snails. They could not be persuaded to enter the water. Two young natives (ages about 16 and 19) were engaged to clear the portion measuring about twenty yards by twenty-five yards. After having been at it for two hours, they were continually scratching the more tender parts of their bodies. Needless to say, they never cleared the pool. Their faeces and urine were examined the next day, two months and three months later, but always with negative results. Although these findings are perhaps by no means conclusive, they seem to disprove the possibility of man normally functioning as a definitive host for *S. mattheei*. At first I was inclined to suspect this parasite as responsible for those cases of intestinal schistosomiasis, without cystic implication, associated with terminal-spined eggs as recorded from Central Africa, but my observations in Humansdorp seem to disprove this possibility.

It is undoubtedly noteworthy that, although vesicular schistosomiasis has been known in Port Elizabeth for over half a century [Harley (1864) records the first cases], the infection has never spread to Humansdorp. Dr. Wentzel, a retired medical practitioner, informed me that he had never met with a single case locally.

Schistosomiasis is by no means as widespread in the Cape Province as suggested by the chart (Fig. 584) published in Byam and Archibald. That chart is a misstatement of facts. Judging from the public interest shown in the schistosomiasis question, the disease is probably not as widespread as some would have us believe. The disease seems localized to certain well-defined areas.

THE ACTION OF TARTAR EMETIC, EMETINE HYDROCHLORIDE AND SB. 212 ON "SCHISTOSOMA MATTHEEI" IN THE MERINO.

This is a preliminary communication on the results obtained with certain chemicals against a schistosome infesting sheep and cattle in the Cape Province.

Literature dealing with the treatment of schistosomiasis in sheep is apparently non-existent. Fairley (1924 and 1926) reports on his results with tartar emetic and emetine hydrochloride against *Schistosoma spindalis*, Montgomery 1906, in goats. These goats were experimentally infected. He records that tartar emetic, administered intravenously in doses of 3.9 to 5.5 mg. per kg. body weight and continued daily for sixteen to twenty-six days, is capable of curing *S. spindalis* in goats. Emetine hydrochloride was found to be effective when administered in doses of 0.7 to 1 mg. per kilogram body weight, and continued daily for ten to fifteen days. He observes that this drug proved to be quite as specific as tartar emetic, but is more toxic to the host.

The literature treating with the curative effects of tartar emetic and emetine hydrochloride in human cases is voluminous. Each drug has its champions. Fairley (1926), in a concise but comprehensive summary, enumerates the findings recorded by various workers.

In the discussion which followed Fairley's paper (1926), several of the pioneers in the campaign against schistosomiasis stated their views. Christopherson, a great believer in tartar emetic, expressed the opinion that emetine hydrochloride is neither as efficacious nor as safe as tartar emetic, and that schistosomes may become "fast" or "tolerant" to either of these drugs. He next remarked that Fairley did not mention the direct action of tartar emetic and emetine on the eggs in the tissues, though he (Fairley) indicates that there is an indirect action through the females. Christopherson concluded by stating that tartar emetic acts directly on the parasite and not indirectly through the tissues of the host, as Fairley is inclined to conclude from his experiments with tartar emetic and emetine hydrochloride on schistosome cercariae *in vitro*.

Day followed and observed that, weight for weight, boys required larger doses than adults. The next speaker was Hodson, who wanted to know whether eosinophilia would not be a more suitable clinical test than the complement fixation reaction, advocated by Fairley. Low referred to the fact that Fairley found, in treated animals, males with the females absent or reduced in numbers, and concluded that some of the clinically cured human cases might still harbour males. He concluded by pointing out the importance of antimony in Tropical Medicine, where its compounds are to-day utilized for curing *schistosomiasis*, *trypanosomiasis*, *kala-azar*, and *ulcerating granuloma*.

Clayton Lane observed that Fairley's findings indicated that, as with quinine and the malaria parasites, it was not the drug which killed the parasites, but a derivative of it formed in the body of the host. Wenyon was not prepared to accept Fairley's conclusions as regards the indirect action of the drugs, and rightly suggested that the serum of an animal which had been treated should be compared with normal serum as regards its lethal properties on cercariae *in vitro*. Manson-Bahr concluded the discussion by stating that he had found Von Heyden "471" valuable in kala-azar, but quite useless against schistosomiasis.

That the antimony compounds do act indirectly on the schistosomes cannot be wholly denied and is evidently not without a parallel in helminthology. The action of carbon tetrachloride on the members of the genus *Fasciola* seems to be indirect. It is now generally accepted that this drug has no action on the immature flukes located outside the lumen of the bile-ducts. While testing carbon tetrachloride against the common liver-fluke of sheep in the eastern Transvaal in 1926, I observed that the flukes, collected from the gall-bladder and the bile-ducts twenty hours after the administration of the drug, appeared with the posterior portions of their bodies necrosed. The tissues in the immediate neighbourhood of the suckers appeared apparently normal (Fig. 41). It was undoubtedly the degenerative changes in the cuticle and the posterior portion of the body that rendered the cuticular spines functionless and led to the expulsion of the parasites. Liver-flukes were then collected from sheep at the municipal abattoir at Ermelo and dropped into pure carbon tetrachloride and others into a mixture of this chemical and raw linseed-oil. They were kept in these fluids for twenty hours without showing the changes observed *in vivo*. This, together with the fact that immature flukes escaped, seems to indicate that carbon tetrachloride acts indirectly on *Fasciola*, and that the compound responsible for the death of the parasite is formed after the drug reaches the bile-ducts.

With an increased dose (the dose required to kill liver-flukes is 1 c.c. of carbon tetrachloride) the degenerative changes were more marked after twenty hours than with the minimum dose.

Some authors have attributed the fatality following the use of carbon tetrachloride in infected animals to toxins liberated by the decomposing flukes. Experiments at Onderstepoort have shown that young cattle in good condition and free of fluke infection are very susceptible to carbon tetrachloride and could be poisoned by a dose (10 c.c.) which produced no visible ill-effects in old Merino ewes which were badly infected with flukes.

Minot (1927) has suggested that the lack of calcium in an animal's body may increase the toxicity of the drug. Certain workers on the mineral requirements of the animal body claim to have proved that the presence of magnesium has an influence on the calcium metabolism. This may explain the apparent decrease in the toxicity of carbon tetrachloride when magnesium sulphate is administered simultaneously with the drug.

The failure of male-fern preparations to kill the immature flukes which are still located in the liver tissue outside the bile-ducts suggests that the active principle of these drugs acts indirectly.

THE INFLUENCE OF TARTAR EMETIC ON THE SCHISTOSOMES *IN VIVO*.

Two sheep, in poor condition and weighing 39 and 43 pounds respectively, received intrajugularly 36 grains of tartar emetic. Each animal received 4 c.c. of a 6 per cent. solution every other day. When the day for injection fell on a Sunday, the dose was administered on the Monday. The first dose was received on the 23rd April, 1928, and the last one on the 9th May, 1928. One animal was killed on the 28th May, 1928, for autopsy and showed a few very small schistosomes, in pairs and singly, in the smaller veins of the mesentery. A few were also collected from the hepatic ramifications of the portal vein, the right ventricle, and the pulmonary arteries and their branches.

Emboli containing dead parasites were numerous in the ramifications of the portal vein in a markedly cirrhotic and pigmented liver. Emboli, caused by the arrest of dead schistosomes in the smaller branches of the pulmonary arteries, were frequent in both lungs. Males and females were present in equal numbers. The females, being dark in colour and thinner than the males, had to be specially looked for.

The effect of tartar emetic in influencing the habitat of this schistosome has been stressed in another publication (Le Roux, 1929).

SOMATIC CHANGES OBSERVED IN SCHISTOSOMES SUBJECTED TO THE ACTION OF TARTAR EMETIC *IN VIVO*.

I have been unable to trace any communication recording somatic changes in schistosomes subjected to the lethal action of either tartar emetic, emetine hydrochloride, emetine periodide, Sb. 212, carbon tetrachloride, or any other drugs. The presence of deformed eggs *in utero* has been recorded from females that had been subjected to drugs injurious to schistosomes.

The microscopic examination of specimens, recovered from the treated sheep, showed marked somatic changes from the normal. The parasites were much shrunken both in length and in breadth. The length was reduced to approximately one-fourth of the normal. The intestinal caeca, in the male, presented a most tortuous course, indicating that shrinkage in the length of the gut was not proportional to that manifested by the body. This latter phenomenon was even more pronounced in the dead specimens arrested in the liver and in the lungs.

The testes were reduced in size and their contents were more translucent than normally.

The muscular layers of the body were reduced in depth.

The microscopical examination of the females revealed conspicuous changes in the genital organs. The uterus contained either no eggs, or only a few. The eggs present were almost invariably reduced in size and with the spine abnormally shaped (Figs. 37, 38, 39, and 40). The ovary was decreased in size, and its contents abnormally translucent. The common intestinal caecum, empty and tortuous, was surrounded by vitelline glands which were no longer of that characteristic dark colour as seen in the normal parasite.

THE ACTION OF TARTAR EMETIC ON THE OVA *IN VIVO*.

Christopherson's view has been stated. It has its supporters and its opponents. Neither group has proved its case beyond dispute. Much more experimental work is to be undertaken to prove or disprove either the one or the other view held. Before their hypothesis can be accepted as proved Christopherson and his supporters will have to ascertain the time required by the egg to reach the lumen of the organ in the wall of which it was deposited.

Maciel (1926) records that the eggs of *S. mansoni* are passed out of the body normally within twenty-four hours of being laid. He further observes that a low barometric pressure increases the egg output. He attributes this increase to influence on the worm. There is no proof that the female is induced to lay more eggs. The passage of the ova through the tissues is more probably affected.

The faeces of the autopsied sheep yielded live miracidia up to the time of killing. From the fifteenth day after treatment there was a most marked decrease in the amount of bloodstained mucus passed. When the animal was autopsied there were still eggs, containing live miracidia, present in the mucosal scrapings. There was a most significant decrease in the number of eggs present in the faeces. The other sheep passed no live eggs after the fifth week.

EMETINE HYDROCHLORIDE AND SB. 212.

Emetine hydrochloride was administered as recommended for goats by Fairley (1926). The results on the two animals used were most disappointing. The presence of schistosomes, slightly reduced in size, in the lungs of the animal killed a month later proves that it had some effect. The second sheep was killed four months later and normal schistosomes were recovered.

The price of this drug will limit its use in the control of schistosomiasis in domestic stock.

Sb. 212 was tried in double the dose recommended by Khalil for humans. The results were even more disappointing than with emetine hydrochloride. No other drugs have been tried to date.

The two last-mentioned drugs can be administered subcutaneously or intramuscularly without ill-effects, as has been proved by experiments on normally healthy sheep.

Excessive doses of emetine hydrochloride caused a marked hyperaemia of the membranes of the mouth, pharynx, and larynx. On continuing the dose, the hyperaemia was followed by oedema and ultimately ulcerations and necroses of the mucosa of the parts mentioned above. These lesions were accompanied by similar lesions of the mucosa of the oesophagus, rumen, reticulum omasum, abomasum, and the small intestine. The two last mentioned were badly affected. Degenerative changes were present in the liver.

THE QUANTITY OF TARTAR EMETIC REQUIRED TO EFFECT A CURE IN INDIVIDUAL CASES.

It has been repeatedly stated that, weight for weight, boys require more than adults. This may be due to (i) the absence in boys of a substance which interacts with the drug and forms a compound or compounds lethal to schistosomes; that the drug may indirectly affect the parasites seems quite probable; and (ii) the reduced concentration of the drug in the circulation.

It seems quite logical to expect that the minimum amount required to kill the parasites in an adult will also be the minimum lethal dose for those parasitizing children.

In Byam and Archibald (1923) the treatment recommended for humans consists of two courses with an interval of seven days between them. Each course consists of a series of five intravenous injections, one being given every second day. According to them, adults will have received 18.5 grains and boys about 13 grains of tartar emetic at the end of the second course. Khalil (1926) gives three injections per week for three weeks. The tartar emetic is given in a 6 per cent. solution (1 c.c. of this solution contains about 1 grain of the drug). His first dose is 0.5 c.c. This is increased to 1 and 1.5 c.c. for the second and third doses respectively. For the rest of the course the dose is 2 c.c.

Khalil's system is much preferable to that recommended in Byam and Archibald (1923). The interval of seven days undoubtedly favours the survival of parasites.

Khalil found sodium antimony tartrate as efficient as tartar emetic. This salt is more expensive and much less stable than the latter. He also tried Sb. 212, and recommends it for children and fat individuals where intravenous injections are not advisable, but where intramuscular injections are more practical. This drug has been used on sheep in the field and had, according to the farmer, beneficial effects. My experiments at this Institute did not verify this. It must be stated, though, that the worse affected animals were bought for experimentation.

The Sb. 212 used had been in store for over two years, and several of the bottles showed that the salt had changed to a partly insoluble mixture. On dissolving it in water a reddish deposit was precipitated.

THE TECHNIQUE EMPLOYED FOR INTRAVENOUS ADMINISTRATION OF TARTAR EMETIC IN SHEEP.

The sheep to be treated are removed from the general flock and the wool clipped off the right side of the neck. The wool is closely clipped over the course of the jugular vein. This is best accomplished with curved scissors.

The following morning the first injections are given and repeated every other day. The first injection of 2 c.c. of a 6 per cent. solution is followed by a second of 3 c.c. and a third of 4 c.c., which is continued until the tenth injection has been given. The 6 per cent. tartar emetic should be freshly prepared every time and sterilized by boiling for a few minutes. By using freshly prepared solutions hardly any oedema develops at the site of inoculation, and the ten injections can be administered on the same side. Where several sheep are to be inoculated, it is advisable to use a 20 c.c. syringe and to have the solution ready in bottles holding 100 c.c. each. A few spare sterilized syringes and a needle for every five sheep should be at hand.

For controlling the animal on its side on the ground, two assistants are required. One holds the animal's feet and the other presses on the jugular vein at the base of the neck and holds the syringe while the needle is inserted. The animal's head and neck are controlled by the right knee and the left foot of the operator kneeling at its side. The right knee is placed behind the animal's neck and the heel of the left foot pushed against the jaw holds the head extended in a straight line with the neck. The needle is inserted into the distended vein, and as soon as blood flows from it the syringe is connected, the assistant releases his hold on the vein, the required amount of solution is injected, and the sheep is released to wander off at ease.

With willing assistants it is possible to do at least eighty or more sheep an hour.

When emetine hydrochloride is used intramuscularly, it is best administered into the muscles of the thigh. A much thinner needle is now used. The selected limb should be firmly held during the operation.

These operations should, for preference, never be attempted in the kraal or shed as is commonly met with in South Africa. When the operation is performed in a kraal or near it, there is a great risk of inoculating the animals with virulent gas-gangrene producing organisms.

Prior to the operation, the site of inoculation is rubbed with cotton wool soaked in 5 per cent. carbolic acid in soft water.

OBSERVATIONS ON THE CONTROL OF SCHISTOSOMIASIS IN MAN AND ANIMAL.

Within the last fifty years the life-cycles of at least twenty trematodes parasitizing man and his domestic mammals and birds have been determined. The life-cycles of seventeen species have been determined since 1915.

Various authors, bearing in mind these findings, have hypothecated measures for the control and the eradication of trematode diseases. Some of the measures suggested have evidently never been put to the test; at least, there are no records of their successful application. Others seem rather impracticable for general application.

That all mammalian schistosomes require molluscs for their successful propagation in a given locality can no longer be disputed. It is, therefore, evident that the vulnerable points in their life-cycles, to be aimed at, are:—

(1) *The adult parasite*, which may be successfully exterminated by irrigating the veins of the infected vertebrate host with tartar emetic or any other drug lethal to schistosomes.

(2) *The miracidia*, which should be prevented from reaching its hosts by preventing infected urinary and faecal matter from gaining access to the snail-infested waters.

(3) *The intermediate host*, which can be eradicated by the administration of poisonous substances to the infested waters, by drying, or by other means.

(4) *The cercariae*, which should be prevented from reaching the definitive host.

(1) THE ERADICATION OF THE ADULT SCHISTOSOMES FROM THE DEFINITIVE HOST.

Although MacDonagh had good results with tartar emetic in a few cases during the Boer war, he only published his findings, to which he seemed to attach little importance, in 1917. To Christopherson (1917), from Khartoum, is due the credit of bringing the use of tartar emetic to the notice of a world clamouring for a specific cure against that debilitating disease *Schistosomiasis* (Vel *Bilharziasis*).

Hutchison (1913) was evidently the first to note the efficacy of emetine hydrochloride against the Eastern schistosome (*S. japonicum*). It has since been proved lethal to other schistosomes. Most practitioners seem to prefer using tartar emetic to emetine hydrochloride, which is said to be somewhat toxic to the host.

Organic compounds of antimony have been experimented with and good results are claimed for Bayer *Sb.* 212 (Khalil, 1926), and *Antimosan* [Orenstein (1928), Specht (1926), and others]. Cawston (1929) refers to Orenstein's findings, and expresses the view that antimosan is likely to prove as disappointing as several other antimony preparations. Khalil (1926) reports favourably on the use of sodium antimony tartrate. He has also used antimosan, stibenyl, and urea stibamine, but refrains from drawing conclusions. Gordon (1926) reports favourably on the use of emetine periodide in the treatment of *S. haematobium* infections in children. This is a very expensive and rather unstable preparation.

Tootell (1923) is not favourably impressed with mercurochrome 220 soluble. Miyagawa (1926) has found stibnal and "neostibnal" effective in the treatment of *S. japonicum*. Stibnal is evidently sodium antimony tartrate and is acid in reaction, while the "neostibnal" is stibnal rendered slightly alkaline.

Cawston (1928) records good results with carbon tetrachloride. I have tried this drug on infected sheep, but without success. Shattuck and Willis (1928) report that antimony sodium thioglycollate and antimony thioglycollamide had favourable effects in cases of urinary schistosomiasis. They claim that these drugs are much less toxic than tartar emetic.

Christopherson (1928) is convinced that the only method of eradicating schistosomiasis from a given locality is to rid both snails and humans of the infection by irrigating the veins of the definitive host with tartar emetic. He observes that South Africa is adopting this line of action by treating the school children in the endemic areas.

(2) PREVENTING THE MIRACIDIA FROM REACHING THEIR HOSTS.

Blacklock (1925) has rightly remarked that endemic *schistosomiasis* is a sign of inadequate education in hygienic principles. The same holds in South Africa, where the insanitary disposal of human excreta is also responsible for the prevalence of *cysticercosis* in cattle and pigs. Sanitation in some of our villages leaves much to be desired.

In the life-cycle of the human schistosomes the miracidia can be successfully dealt with. In domestic stock the prevention of water-pollution with animal excreta would not be so easy. On some farms there are only a few snail-infested pools, and these should be fenced off. Municipalities should pass by-laws prohibiting the bathing and fishing in streams or rivers within the municipal boundary. The control of water-pollution should be more strictly conducted than is at present the case.

(3) CONTROL AND ERADICATION OF THE INVERTEBRATE HOST.

Before an attack on the snails is launched, the species responsible for the transmission of the worm must be conclusively proved, or much energy and money may be wasted. A careful study of the bionomics and the susceptibilities of the intermediate hosts may suggest the means by which they can be most readily eradicated.

Methods which have been suggested for the eradication of snails are:—

(i) *The Use of Chemicals lethal to Fresh-water Snails.*

Thomas (1883) suggests dressing the ground with lime or salt, or both, to destroy the snails responsible for the transmission of *F. hepatica*. Leiper (1915) suggests the use of chemical agents such as ammonium sulphate. Chandler (1920) observes that one part of copper sulphate to from 500,000 to 2,000,000 of water destroyed several species of snails within two days. Leiper (1922) notes that copper sulphate in the dilution 1 in 5,000,000 kills *Bulinus contortus* and *Planorbis boissyi,* while *Lymnaea truncatula* required a dilution of 1 in 2,000,000. Walton and Jones (1925) recommend the use of copper sulphate, in one-half per cent. dilution, against *Lymnaea trunculata.* They did not find ammonium sulphate as effective.

Other chemicals which have been successfully used are slaked lime and calcium cyanamid in concentrations of 0.1 per cent. Nagano (1926) found a 0.2 per cent. mixture of "lime nitrogen" efficacious against snails in Japan. Cawston (1928 *a*) states that the plant *Tephrosia macropoda* is highly toxic to *Physopsis* sp. and suggests that it should be utilized for eradicating the intermediate hosts of schistosomes. In a later communication he states that the active principle of the plant would appear to be about a hundred times more toxic than copper sulphate is for *Physopsis.*

I have tried copper sulphate in a dilution of about 1 in 2,000,000 on *Physopsis africana* var. *globosa* in a pool, and it killed all of them in eighteen hours. Thus far I have invariably found *Physopsis* in pools and backwaters in permanent collections of water. As in the Transvaal these collections are at their lowest in winter, it is evident that this is the time for poisoning the snails. At Humansdorp the flow in the river was lowest during the summer (the non-raining season). The non-rainy season should be selected for the attack on the snails.

(ii) *Subjecting the Snails to Sudden Drying.*

Leiper (1915) suggests killing off *Bulinus* by subjecting it to sudden drying in the irrigation canals. This mode of killing snails may be practical in irrigation canals in Egypt, but cannot be utilized in the schistosome-infected areas of the Union. *Lymnaea natalensis* may be controlled on liver-fluke infested farms by draining the marshy pastures.

(iii) *The Keeping of Domestic Ducks.*

Keatinge recommends the keeping of flocks of domesticated ducks for eradicating the snails. Cawston claims to have had good results with ducks. This mode of snail eradication needs closer investigation. There are hardly any experiments on record which prove the use of the domestic duck as a means of controlling the increase of the molluscs. My personal experience is that *Lymnaea natalensis* may flourish in the pools frequented daily by ducks.

(4) THE CERCARIAE AND THE DEFINITIVE HOST.

All pools known to be infested with schistosome cercariae should be avoided. In the case of the animal schistosomes, the pool or pools may be fenced off. If there is no other water available for drinking the stock, the water in one or more of the pools should be treated with copper sulphate to kill the intermediate hosts and the cycle thus arrested.

According to Leiper (1915), the cercariae can survive for only forty-eight hours. Where water is pumped from infected pools into tanks, it should not be used for two days. The use of "tabloids" of sodium bisulphate, 16 grains to a pint of water, is said to kill off the cercariae and renders the water safe for human consumption.

The campaign against schistosomiasis must be conducted energetically, and both the definitive and the intermediate hosts should receive due attention. It is undoubtedly a waste of public funds to treat school children while the adults and the molluscs roam about unattended. Khalil (1927) records the successful eradication of bilharziasis from an endemic area by the use of copper sulphate.

During a recent visit by some northern Transvaal farmers to this Institution it became evident that they knew little about the cause and prevention of urinary schistosomiasis. Most of them had never even seen the snail responsible for the transimssion of *S. haematobium*. Some of them questioned me for quite a time. One of the more elderly men ultimately asked me whether the medical practitioners did not know "all about it," or, if they did, why they did not tell them. Some of my experiences with medical practitioners prove that the farmer had reason to ask that question.

The endemic areas of the country are evidently flooded with leaflets dealing with the cause and spread of haematuria, but an ocular demonstration of the worms will impress the inhabitant more than the leaflets. The farmers should be made to realize that the present insanitary conditions on their farms leave much to be desired. The following quotation from a recent Editorial in the *Journal of the Medical Association of South Africa* is pertinent:—"We have tinkered with many subjects—with public health, medical supervision of schools and scholars, malaria prevention, medical service for rural communities, and many other matters—but we have not tackled one of these with energy, foresight, and the desire to make the public see that our point of view is, after all, the national point of view. In the future we must take our responsibilities much more seriously, subscribing to Larrey's formula that 'a physician is a priest who should preach and practise.'"

The same writer also makes the statement: "It has been said that we have larger sums of money devoted to animal research than to medical research."

The treatment of school children will, according to a recent newspaper announcement, be continued this year, but let us hope that due attention will be paid to the native and the snail.

I was recently told by a gentleman from Zululand that the charge for the course of treatment for schistosomiasis is £15. This is, according to the *Star* of Johannesburg, also the charge in some parts of the Transvaal. Very few of the poor whites can afford this, especially when they have more than one child infected. According to some reports, the control of *schistosomiasis* is of national importance. The disease is undoubtedly on the spread. This spread must be attributed to the movements of infected humans.

The practice of trekking with sheep about the country in times of drought has been forcibly demonstrated as a means of disseminating helminths. During the last serious drought several flocks were grazed in the endemic area in the Humansdorp District. Most of these flocks, fortunately, returned to areas claimed to be free of molluscs.

THE SOUTH AFRICAN FRESH-WATER SNAILS RESPONSIBLE FOR THE SPREAD OF TREMATODE DISEASES.

Photographs of various South African freshwater molluscs are included for the information of those interested. I would like to point out that the distribution of molluscs in the Union of South Africa is very imperfectly known and that our field colleagues can supply much of the information wanted. The bionomics of the various species needs further study and should receive the attention of the man on the spot.

Live snails may be forwarded to this Laboratory for identification, by animal experimentation, of the cercariae present. The snails, packed in slightly moist water plants, travel well by post or passenger train.

The species photographed are named as identified for us. It must be pointed out that the leading malacologists seem unable to reach an agreement with regard to the nomenclature and the definition of the genera and the species. Generic names of African molluscs such as *Bulinus* and *Lymnaea* are often misspelt as *Bullinus* and *Limnaea*. Let us hope that the malacologists and the International Commission of Zoological Nomenclature will soon rectify matters.

The freshwater molluscs of South Africa need revision badly, but such revision can only be attempted when the material is available.

BIBLIOGRAPHY.

DEALING WITH TREATMENT.

BAUJEAN, R. (1921). "Traitement des bilharzioses, intestinale et vésicale, par l'émétique en injections intraveineuses," *Bull. Soc. Path. Exot.*, Vol. 14, p. 299.

BLACKLOCK, D. B. (1925). "Endemic Goitre and Schistosomiasis in Sierra Leone," *Trans. Roy. Soc. Trop. Med. and Hyg.*, Vol. 18, No. 8, pp. 406-427.

BONNE, C. (1919). "Has Emetine any Influence on the Schistosomes?" *Trans. Roy. Soc. Trop. Med. and Hyg.*, Vol. 12, p. 82.

BONNET, M. (1921). "Un cas de bilharziose vésicale traitée par les injections intraveineuses d'émétine," *Jl. d'Urol.*, Paris, Vol. 12, p. 16.

BRUMPT, E. (1922). "Précis de Parasitologie." (Masson & Cie, Paris.)

CAWSTON, F. G. (1919 *a*). "A Case of Bilharziasis in Natal treated by Tartar Emetic," *Lancet*, Vol. 2, pp. 873-874.

CAWSTON, F. G. (1919 *b*). "A Specific for Schistosomiasis," *S. African Med. Rec.*, Vol. 17, No. 20, pp. 315-316.

CAWSTON, F. G. (1919 *c*). "Case of Bilharzia Disease complicated by Stone, cured by Tartar Emetic Treatment," *Jl. Trop. Med. and Hyg.*, Vol. 22, No. 18, pp. 174-175.

CAWSTON, F. G. (1920). "Treatment of Bilharzia Disease with Tartar Emetic in South Africa," *Lancet*, Vol. 1, p. 865.

CAWSTON, F. G. (1921). "A Patient Harbouring *Schistosoma japonicum*, cured by Tartar Emetic," *Jl. Trop. Med. and Hyg.*, Vol. 24, p. 13.

CAWSTON, F. G. (1922). "The Emetine Treatment for Bilharzia Disease," *Jl. Trop. Med. and Hyg.*, Vol. 25, p. 112.

CAWSTON, F. G. (1924 *a*). "Treatment of Bilharziasis" (Correspondence), *Brit. Med. Jl.*, Vol. 2, p. 299.

CAWSTON, F. G. (1924 *b*). "Antimony Tartrate in Bilharzia" (Correspondence), *Lancet*, Vol. 2, p. 831.

CAWSTON, F. G. (1926). "The Use of Emetine in Treating Bilharzia Disease in Children," *Jl. Roy. Arm. Med. Corps*, Vol. 46, No. 1, p. 57.

CAWSTON, F. G. (1928). "Carbon Tetrachloride in Schistosomiasis," *Trans. Roy. Soc. Trop. Med. and Hyg.*, Vol. 22, No. 3, pp. 245-248.

CAWSTON, F. G. (1929). "The Non-Toxic Treatment of Bilharzia Disease," *Jl. Trop. Med. and Hyg.*, Vol. 32, No. 4, p. 47.

CHRISTOPHERSON, J. B. (1918). "The Successful Use of Antimony in Bilharziasis administered as Intravenous Injections of Antimonium Tartaratum (Tartar Emetic), *Lancet*, Vol. 2, pp. 325-327.

CHRISTOPHERSON, J. B. (1918). "Intravenous Injections of Antimonium Tartaratum in Bilharbiosis," *Brit. Med. Jl.*, Vol. 2, pp. 652-653.

CHRISTOPHERSON, J. B. (1919a). "Antimony in Bilharziosis" (Correspondence), *Lancet*, Vol. 1, p. 79.

CHRISTOPHERSON, J. B. (1919b). "Antimony Tartrate in Bilharziosis and Tachycardia," *Brit. Med. Jl.*, pp. 480-481.

CHRISTOPHERSON, J. B. (1919c). "Antimony Tartrate for Bilharziasis: A Specific Cure," *Lancet*, Vol. 1, pp. 1021-1023.

CHRISTOPHERSON, J. B. (1919d). "The Cure of Bilharzia Disease by the Intravenous Injection of Antimony Tartrate," *Jl. Trop. Med. and Hyg.*, Vol. 22, No. 12, pp. 113-114.

CHRISTOPHERSON, J. B. (1919e). "Intravenous Injections of Antimony Tartrate in Bilharziasis" (Correspondence), *Lancet*, Aug. 16, p. 299.

CHRISTOPHERSON, J. B. (1919f). "The Cure of Bilharzia Disease by Intravenous Injections of Antimony Tartrate: The Prophylactic Use of the Drug," *Brit. Med. Jl.*, Oct. 19, p. 484.

CHRISTOPHERSON, J. B. (1920). "Bilharzia Disease: The Sterilization of the Ova during the Course of Cure by Antimony (Tartrate)," *Jl. Trop. Med. and Hyg.*, Vol. 23, No. 13, pp. 165-167.

CHRISTOPHERSON, J. B. (1921). "The Intravenous Injection of Antimony Tartrate in Japanese Bilharzia Disease," *Brit. Med. Jl.*, Vol. 2, p. 551.

CHRISTOPHERSON, J. B. (1923a). "The Curative Dose of Antimony Tartrate in Schistosomiasis (Bilharzia Disease)," *Brit. Med. Jl.*, Vol. 2, p. 1254.

CHRISTOPHERSON, J. B. (1923b). "The Treatment of Bilharzia Disease," *S. African Med. Rec.*, Vol. 21, p. 566.

CHRISTOPHERSON, J. B. (1924). "The Treatment of Bilharzia Disease," *Lancet*, Vol. 1, p. 1071.

CHRISTOPHERSON, J. B. (1925). "The Cure of Schistosomiasis by the Intravenous Injection of Antimony Tartrate," *Indian Med. Gaz.*, Vol. 60, p. 108.

CHRISTOPHERSON, J. B. (1925). Discussion of Blacklock's (1925), pp. 424-425.

CHRISTOPHERSON, J. B. (1927). "Bilharzia Ova and the Test Tube," *Brit. Med. Jl.*, Mar. 5, pp. 418-419.

CHRISTOPHERSON, J. B., AND GLOYNE, S. R. (1926). "The Biochemical Action of Intravenous Antimony Tartrate Injections," *Lancet*, Vol. 1, p. 227.

CHRISTOPHERSON, J. B., AND NEWLOVE, F. R. (1921). "Laboratory and Other Notes on Seventy Cases of Bilharzia treated at the Khartoum Civil Hospital by Intravenous Injections of Antimony Tartrate," *Jl. Trop. Met. and Hyg.*, Vol. 22, No. 14, pp. 129-144.

CHOPRA, R. N. (1926). "A Preliminary Note on the Pharmacological Action of Some Organic Antimony Derivatives," *Indian Med. Gaz.*, Vol. 61, No. 4.

CHOPRA, R. N., AND CHOSH, B. N. (1921). "The Therapeutic of Emetine," *Indian Med. Gaz.*, Vol. 57, pp. 248-252.

CHOPRA, R. N., AND NAPIER, L. E. (1923). "The Therapeutic of Antimony," *Indian Med. Gaz.*, Vol. 57, No. 1, pp. 1-7.

CHOPRA, R. N., CHOSH, B. N., AND DE, P. (1924). "Toxicity of Emetine," *Indian Med. Gaz.*, Vol. 59, p. 338.

COLLIGAN AND MONZIOLS (1919). "Un cas de Bilharziose vésical traité par des injections souscutanées de Chlorhydrate d'Emétine," *Bull. et Mém. Soc. Med. Med. Hôpit. de Paris*, Vol. 35, No. 27, pp. 796-797.

CUSHNY, A. R. (1918). "Pharmacology and Therapeutics," Seventh Edition. (J. & A. Churchill, London.)

CURSON, H. H. (1922). "Nagana and Tartar Emetic Treatment," *Jl. Dept. Agric.*, Union of S. Africa, Vol. 5, p. 249.

CURSON, H. H. (1928). "Nagana in Zululand," *13th and 14th Reports, Dir. Vet. Educ. and Res.*, Part 1, pp. 382-386.

DALE, H. H. (1915). "A Preliminary Note on Chronic Poisoning by Emetine," *Brit. Med. Jl.*, Vol. 2, p. 895.

DALE, H. H. (1924). "Progress and Prospects in Chemotherapy," *Lancet*, Vol. 2, p. 257.

DAY, H. B. (1921). "The Out-patient Treatment of Bilharziasis with an Analysis of 1,000 Cases," *Lancet*, Vol. 1, pp. 525-529.

DAY, H. B. (1924). "Anthelminthic Work in Egypt," *Lancet*, Vol. 1, p. 435.

DIAMANTIS (1917). "Sur un nouveau Traitement de l'hématurie bilharzienne en Egypte," *Jl. d'Urol.*, Paris, Vol. 7, p. 17.

DOBELL, C., AND LAIDLAW, P. P. (1926). "The Action of Ipecacuanha Alkaloids on Entamoeba Histolytica and some other Entozoic Amoebae in Culture," *Parasit.*, Vol. 18, pp.

EDITOR, *LANCET* (1916). "Thymobenzene in Bilharziasis," *Lancet*, Vol. 1, p. 698.

EDITOR, *LANCET* (1921). "Bilharziasis and Its Treatment," *Lancet*, Vol. 1, No. 11, pp. 545-546.

EDITORIAL (1928). "Bilharziasis in Egypt," *Jl. Trop. Med. and Hyg.*, Vol. 31, No. 4, pp. 49-50.

ERIAN, A. (1919). "The Treatment of Bilharziosis by Massive Doses of Emetin," *Practitioner*, Vol. 103, No. 5, pp. 391-393.

FAIRLEY, N. H. (1919). "A Report on Three Cases of Bilharziasis treated with Tartar Emetic," *Med. Jl. Australia*, Dec. 20.

FAIRLEY, N. H. (1919). "Egyptian Bilharziasis: Its Recent Pathology, Symptomatology, and Treatment," *Proc. Roy. Soc. Med. Occ. Lect.*, Vol. 13, No. 1.

FAIRLEY, N. H. (1924). "Experimental Studies in Bilharzia Therapy (*S. spindalis*): A Preliminary Report," *Indian Med. Gaz.*, Vol. 59, pp. 377-385.

FAIRLEY, N. H. (1925). "Complement Fixation with Bilharzia. Part I: The Lipoidal Nature of Cercarial Antigen as used in the Complement Fixation Test for Mammalian Bilharziosis," *Jl. Path. and Bact.*, Vol. 28, p. 591.

FAIRLEY, N. H. (1926). "Studies in Chemotherapy and Immunity Reactions of Schistosomiasis," *Trans. Roy. Soc. Trop. Med. and Hyg.*, Vol. 20, No. 4, pp. 236-267.

FAUST, E. C. (1923). "Treatment of *Schistosoma japonicum*," *China Med. Jl.*, Vol. 37, pp. 847-849.

GARIN, H. (1920). "Statistical Remarks on the Treatment of Bilharziasis by Tartar Emetic," *Med. Jl. S. Africa*, Vol. 15, No. 8, pp. 179-180.

GORDON, R. M. (1926). " Emetic Periodide in the Treatment of *S. haematobium* Infections amongst West African Children," *Ann. Trop. Med. and Parasit.*, Vol. 20, pp. 229-237.

INNES, A. (1919). " Treatment of Bilharzial Infection by Tartar Emetic," *Brit. Med. Jl.*, Vol. 2, p. 340.

KHALIL, M. (1926). " A Comparative Study of the Methods in the Treatment of Bilharziasis, with a Report on a New Remedy, Bayer Sb. 212," *Arch. f. Schiffs u. Trop. Hyg.*, Vol. 20, No. 9, pp. 451-467.

KHALIL, M. (1927). " Bilharzia Ova and the Test Tube," *Brit. Med. Jl.*, Apr. 9, pp. 702-703.

KHALIL, M. (1928). " Accidents and Complications occurring during the Treatment of Bilharziasis by Antimony Compounds," *Jl. Egypt. Med. Assoc.*, Vol. 11, No. 3, pp. 97-106.

LAMPE, P. H. (1926). " Bilharziasis Treatment," Abst. in *Trop. Dis. Bull.*, Vol. 23, No. 10, pp. 749-750.

LASBREY, F. O., AND COLEMAN, R. B. (1921). " Notes on One Thousand Cases of Bilharziasis Treated by Antimony Tartrate," *Brit. Med. Jl.*, Vol, 1, p. 307.

LASBREY, F. O., AND COLEMAN, R. B. (1924). " Treatment of Bilharziasis by Antimony Tartrate," *Brit. Med. Jl.*, Vol. 2, pp. 907-908.

LEE, C. V. (1925). " The Treatment of Schistosomiasis," *China Med. Jl.*, Vol. 39, No. 4, pp. 321-331.

LIBBY, W. E. (1923). " Tartar Emetic in Schistosomiasis," *China Med. Jl.*, Vol. 37, No. 2, p. 158.

LOW, G. C. (1919). " A Case of Bilharzial Disease treated by Intravenous Injections of Antimonium Tartaratum," *Jl. Trop. Med.*, Vol. 22, p. 93.

LOW, G. C., AND NEWHAM, H. B. G. (1919). " A Series of Cases of Bilharziasis treated by Intravenous Injections of Antimonium Tartaratum," *Lancet*, pp. 633-636.

MACIEL, H. (1925). " Treatment of Intestinal Schistosomiasis," Abst. in *Trop. Dis. Bull.*, Vol. 23, No. 10, p. 751.

MADDEN, F. C. (1921). In " The Dictionary of Practical Medicine," edited by M. Morris, F. Langmead, and G. M. Holmes, Vol. 3, pp. 158-164. (Waverley Book Co., Ltd., London.)

MAROTEL, G. (1927). " Parasitologie Vétérinaire." (Baillière et Fils, Paris.)

MAURIAC, P., AND BOYER, R. (1921). " Experimental Researches on the Treatment of Schistosomiasis by Tartar Emetic Intravenously," Abst. in *Trop. Dis. Bull.*, Vol. 19, No. 3, p. 214.

MAYER, M. (1918). " Behandlung der Bilharziakrankheit mit Emetin," *Münch. Med. Woch.*, Vol. 65, p. 612.

McDONAGH, J. E. R. (1915). " Biology and Treatment of Venereal Disease," London, 1915, p. 349.

McDONAGH, J. E. R. (1918). " Antimony in Bilharziasis," *Lancet*, Vol. 2, p. 371.

McDONAGH, J. E. R. (1920). " The Treatment of Bilharziasis with Antimony," *Jl. Trop. Med. and Hyg.*, Vol. 13, No. 13, p. 165.

McDONAGH, J. E. R. (1923). " Treatment of Bilharziasis with Antimony," *Jl. Trop. Med.*, Vol. 26, p. 119.

MELENEY, H. E., FAUST, E. C., AND WASSELL, C. M. (1925). " A Study of Intensive Antimony Therapy in Schistosomiasis," *Jl. Trop. Med. and Hyg.*, Vol. 28, p. 153.

MINOT, A. S. (1927). " The Relation of Calcium to the Toxicity of Carbon Tetrachloride in Dogs," *Proc. Soc. Exp., Biol. and Med.*, Vol. 24, No. 6, pp. 617-620.

MIYAGAWA, Y. (1926). " *Schistosomum japonicum*: Its Life-history and Treatment with Stibnal," *Japan Med. World*, Vol. 6, No. 9, pp. 229-232.

NISHI, M. (1923). "Experimental Study on the Treatment of *Schistosomiasis japonica* with Tartar Emetic," *Scient. Rep. from Govt. Inst. Infect. Diseases*, Tokyo, Vol. 2, p. 485.

NOGUE ET BOULAY (1923). "Note préliminaire sur l'insuffisance rénale chez les bilharziens. Essais de traitement par l'émétique," *Bull. Soc. Path. Exot.*, Vol. 16, p. 564.

ORENSTEIN, A. J. (1928). "Plasmochin and Antimosan in the Treatment of Malaria and Schistosomiasis," *Jl. Med. Assoc. S. Africa*, Vol. 2, No. 24, pp. 661-662.

PHEASE, R. N. (1923). "Report on the Efficiency of the Treatment of Bilharziosis by Intravenous Injections of Antimony Tartrate after Two Years," *Jl. Roy. Army Med. Corps*, Vol. 41, p. 206.

SCOTT, D. G. (1922). "Treatment of Bilharziasis by Rectal and Vesical Injections of Tartar Emetic," *Tanganyika Territory Ann. Med. Rep.*, Year 1922, Appendix No. 7, p. 92.

SMITH, N. F. (1924). "Urinary Bilharziasis. A Campaign of Diagnosis and Treatment in Dongola Province, Sudan, November, 1921, to March, 1924," *Trans. Roy. Soc. Trop. Med. and Hyg.*, Vol. 18, p. 50.

SPECHT, R. (1926). "Die Behandlung der Bilharziosis mit dem Präparat Heyden 661 (Antimosan)," *Deut. Med. Woch.*, Vol. 52, No. 13, pp. 519-520.

SPENCE, B. H. H. (1925). "The Eradication of Helminthiasis from the Egyptian Army," *Jl. Roy. Army Med. Corps*, Vol. 44, p. 321.

TAYLOR, F. E. (1919). "Intravenous Injections of Antimonium Tartaratum (Tartar Emetic) in Bilharziasis," *Lancet*, Vol. 2, pp. 246-248, *Jl. Roy. Army Med. Corps*, Vol. 33, No. 2, pp. 181-189.

THOMSON, J. H. (1926). "Notes on Schistosomiasis," *Tanganyika Territory Annual Med. and San. Rep.*, year ending 31st December, 1926.

TOOTELL, G. T. (1926). "Comparative Treatment with Mercurochrome 220 Soluble and Tartar Emetic in *Schistosomiasis japonicum*," *China Med. Jl.*, Vol. 40, No. 5, p. 440.

TROLLI (1923). "Three Cases of Bilharziasis treated by Emetine," *Jl. Trop. Med. and Hyg.*, Vol. 26, p. 149.

TSYKALAS (1921). "Neue Wege in der Behandlung der Bilharziakrankheit in Aegypten," *Wien Klin. Woch.*, Vol. 34, p. 579.

TYAU, E. S. (1922). "The Treatment of Asiatic Schistosomiasis," *Nat. Med. Jl., China*, Vol. 8, p. 83.

WALKIERS, J. (1928). "L'application du tartre emetique par voeisdifferentes dans la therapeutique de la bilharziose," *Ann. Soc. Belge Med. Trop.*, Vol. 8, No. 3, pp. 273-290.

WALRAVENS, P. (1927). "Le traitement de la bilharziose," *Ann. Soc. Belge de Méd. Trop.*, Vol. 7, No. 2, pp. 181-183.

WILEY, C. J. (1918). "The Treatment of Bilharziosis by Intravenous Injections of Tartar Emetic" (Correspondence), *Bris. Med. Jl.*, Vol. 2, pp. 716-717.

WILSON, H. F. (1922). "Rectal Administration of Tartrated Antimony in Bilharziasis," *Brit. Med. Jl.*, Vol. 1, p. 137.

WINSLOW, K. (1919). "Veterinary Materia Medica and Therapeutics." (American Veterinary Publishing Co., Chicago.)

DEALING WITH THE LIFE-CYCLES, ETC., OF SCHISTOSOMES.

ALCO, G. (1926). "La *Bilharzia crassa* negli ovini Sardi," *La Clin. Vet.*, Vol. 49, No. 2, pp. 78-81.

ANDERSON, C., EN DE LAGOANERE, J. L. (1927). "La bilharziose en Tunise. Nouveaux essais d'infectation de *Bullinus brocchii* avec des oeufs de *Schistosomum haematobium*," *Arch. Inst. Pasteur de Tunis*, Vol. 16, No. 4, pp. 397-399.

ARCHIBALD, R. G. (1908). "Bilharziosis," *Review of Recent Advances in Tropical Medicine, etc.*, Third Report, Wellcome Research Laboratories, Khartoum, pp. 17-19.

BALFOUR, A. (1914). "Schistosomiasis," *Second Review of Recent Advances in Tropical Medicine, etc.*, Fourth Report, Wellcome Tropical Research Laboratories, Khartoum, pp. 294-299.

BALFOUR, A. (1928). "Notes on Current Literature: Chlorine and Cercariae," *Trans. Roy. Soc. Med. and Hyg.*, Vol. 22, No. 3, p. 297.

BAHR, P. MANSON, AND FAIRLEY, N. H. (1920). "Observations on Bilharziasis amongst the Egyptian Expeditionary Force," *Parasit.*, Vol. 12, pp. 33-71.

BECKER, J. G. (1916). "A Preliminary Note on an Intermediate Host of *Bilharzia haematobium* in the Transvaal, together with a Description of t he Cercariae with which the Mollusc is infected," *Med. Jl. S. Africa*, Vol. 11, No. 9, p. 156.

BEQUAERT, J. (1928). "Mollusks of Importance in Human and Veterinary Medicine," Parts 1 and 2, *Amer. Jl. Trop. Med.*, Vol. 8, Nos. 2 and 3, pp. 165-182, 215-232.

BLACKLOCK, D. B., AND THOMPSON, M. G. (1924 *a*). "Human Schistosomiasis due to *S. haematobium* in Sierra Leone," *Ann. Trop. Med. and Parasit.*, Vol. 18, No. 2, pp. 211-234.

BLACKLOCK, D. B., AND THOMPSON, M. G. (1924 *b*). "Observations on the Classification of certain Schistosoma Cervariae," *Ann. Trop. Med. and Parasit.*, Vol. 18, No. 2, pp. 235-237.

BLACKLOCK, D. B. (1925). "Endemic Goitre and Schistosomiasis in Sierra Leone," *Trans. Rol. Soc. Trop. Med. and Hyg.*, Vol. 18, No. 8, pp. 406-427.

BLACKMORE, H. S. (1928). "Preliminary Note on the Sterilization of Bilharzia-infected Water," *Jl. Roy. Army Med. Corps*, Vol. 51, No. 4, p. 262.

BROCK, G. S. (1893). "On the *Bilharzia haematobia*," *Jl. Path. and Bact.*, Vol. 2, pp. 52-74.

CAMERON, T. W. M. (1928 *a*). "Parasites and Parasitology," Black's *Veterinary Dictionary*, pp. 695-696. (A. & C. Black, London.)

CAMERON, T. W. M. (1928 *b*). "A New Definitive Host for *Schistosoma mansoni*," *Jl. Helm.*, Vol. 6, No. 4, pp. 217-222.

CAWSTON, F. G. (1915 *a*). "Bilharziasis," *Lancet*, Vol. 2, p. 1427.

CAWSTON, F. G. (1915 *b*). "Bilharziosis in Natal," *Brit. Med. Jl.*, Nov. 20, p. 746.

CAWSTON, F. G. (1915 *c*). "Schistosomiasis in Natal, *Jl. Trop. Med. and Hyg.*, Vol. 18, pp. 257-258.

CAWSTON, F. G. (1916 *a*). "Report on the Examination of 1,000 Molluscs in Natal," *Med. Jl. S. Afr.*, Vol. 11, No. 11, p. 197.

CAWSTON, F. G. (1916 *b*). "The Cercariae of Natal," *Jl. Trop. Med. and Hyg.*, Vol. 19, No. 17, p. 201.

CAWSTON, F. G. (1917 *a*). "The Cercariae of Natal," *Jl. Parasit.*, Vol. 3, pp. 131-135.

CAWSTON, F. G. (1917 *b*). "The Cercarial Infection of South African Snails," *Med. Jl. S. Afr.*, Vol. 12, pp. 183-189.

CAWSTON, F. G. (1917 *c*). (Note), *Jl. Parasit.*, Vol. 4, p. 91.

CAWSTON, F. G. (1918 *a*). "The Cercarial Infection of Transvaal Snails," *S. Afri. Med. Rec.*, Vol. 16, pp. 6-8.

CAWSTON, F. G. (1918 *b*). "The Cercarial Infection of the Transvaal," *Parasit.*, Vol. 11, No. 1, pp. 94-97.

CAWSTON, F. G. (1918 *c*). "Freshwater Snails and the Floods," *S. African Med. Rec.*, Vol. 16, No. 11, pp. 167-168.

CAWSTON, F. G. (1918 *d*). "Bilharziasis in Natal," *Parasit.*, Vol. 11, No. 7. pp. 83-93.

CAWSTON, F. G. (1918 *e*). "Some Observations on Blood Parasites," *Jl. Trop. Med. and Hyg.*, Vol. 21, No. 24, p. 241.

CAWSTON, F. G. (1918 *f*). "Bilharziasis in South Africa," *Jl. Amer. Med. Assoc.*, Vol. 70, No. 7, pp. 439-441.

CAWSTON, F. G. (1918 *g*). "The Possible Intermediate Hosts of Schistosoma in South Africa," *Jl. Trop. Med. and Hyg.*, Vol. 21, pp. 69-70.

CAWSTON, F. G. (1919 *a*). "Insanitary Snails at Durban during the Winter Months," *Jl. Trop. Med. and Hyg.*, Vol. 22, No. 20, pp. 189-190.

CAWSTON, F. G. (1919 *b*). "Further Observations in regard to South African Cercariae," *Med. Jl. S. Africa*, Vol. 14, pp. 401-402.

CAWSTON, F. G. (1920 *a*). Quoted by Faust (1926).

CAWSTON, F. G. (1920 *b*). "Some Observations on South African Cercariae," *S. African Med. Rec.*, Vol. 18, pp. 49-51.

CAWSTON, F. G. (1920 *c*). "The Problem of Bilharziasis in South Africa," *Jl. Roy. Army Med. Corps*, Vol. 34, pp. 439-441.

CAWSTON, F. G. (1921). "Some South African Cercariae," *S. African Jl. Nat. Hist.*, Vol. 3, pp. 199-204.

CAWSTON, F. G. (1922 *a*). "The Experimental Infestation of *Physopsis africana*," *Ann. Trop. Med. and Parasit.*, Vol. 16, pp. 207-211.

CAWSTON, F. G. (1922 *b*). "The Experimental Infestation of Freshwater Snails, with Special Reference to the Bilharzia Parasite," *S. African Jl. Sc.*, Vol. 18, pp. 396-399.

CAWSTON, F. G. (1922 *c*). "Freshwater Snails responsible for the Spread of Bilharzia in Portuguese East Africa," *Jl. Trop. Med. and Hyg.*, Vol. 25, pp. 305-306.

CAWSTON, F. G. (1922 *d*). "Some Notes on the Differentiation of Closely-allied Schistosomes," *Parasit.*, Vol. 14, pp. 345-247.

CAWSTON, F. G. (1923). "Occasional Hosts of Some South African Trematodes," *S. African Jl. Sc.*, Vol. 20, pp. 351-353.

CAWSTON, F. G. (1924). "The Source of South African Trematodes," *Ann. Trop. Med. and Parasit.*, Vol. 18, No. 3, pp. 343-346.

CAWSTON, F. G. (1925). "The Identity of the Rarer Schistosomas of Man and Their Intermediate Hosts," *Ann. Trop. Med. and Parasit.*, Vol. 19, No. 2, pp. 215-218.

CAWSTON, F. G. (1926 *a*). "The Problem of the Rhodesian Fluke-Carriers," *Rhodesian Agric. Jl.*, Vol. 23, No. 4, pp. 347-348.

CAWSTON, F. G. (1926 *b*). "Environmental Influences which favour the Development and Spread of the Bilharzia Parasite in South Africa," *Jl. Trop. Med. and Hyg.*, Vol. 29, pp. 89-90.

CAWSTON, F. G. (1927 *a*). "Some Notes on the Effect of Desiccation upon Molluscan Disease-Carriers," *Ann. Trop. Med. and Parasit.*, Vol. 21, No. 1, pp. 35-38.

CAWSTON, F. G. (1927 *b*). "South African Fluke-Carriers," *Jl. Med. Assoc. S. Afr.*, Vol. 1, No. 12, pp. 309-310.

CAWSTON, F. G. (1928). "Bilharzia Infection in South Africa," *Parasit.*, Vol. 20, No. 3, pp. 250-253.

CHANDLER, ASA C. (1926). "A New Schistosome Infection of Man, with Notes on other Human Fluke Infections in India," *Indian Jl. Med. Res.*, Vol. 14, No. 1, pp. 179-182.

CORT, W. W. (1915). "Egg Variation in a Trematode Species," *Jl. Parasit.*, Vol. 2, No. 1, pp. 25-26.

CORT, W. W. (1918). "Adaptability of Schistosome Larvae to New Hosts," *Jl. Parasit.*, Vol. 4, No. 4, p. 171.

CORT, W. W. (1919 *a*). "The Cercaria of the Japanese Bloodfluke, *Schistosoma japonicum*," *Univ. Calif. Pub. Zool.*, Vol. 18, pp. 485-507.

CORT, W. W. (1919 *b*). "Notes on the Eggs and Miracidia of the Human Schistosomes," *Univ. California Publicat. in Zool.*, Vol. 18, No. 18, pp. 509-519.

CORT, W. W. (1921). "The Development of the Japanese Bloodfluke, *Schistosoma japonicum*, in the Final Host., *Amer. Jl. Hyg.*, Vol. 1, pp. 1-38.

CORT, W. W. (1922). "A Study of the Escape of Cercariae from their Snail Hosts," *Jl. Parasit.*, Vol. 8, pp. 177-184.

FAIRLEY, N. H. (1927). "The Early Spontaneous Cure of Bilharziosis (*S. spindalis*) in Monkeys (*Macacus sinicus*) and its bearing on Species Immunity," *Indian Jl. Med. Res.*, Vol. 14, No. 3, pp. 685-700.

FAIRLEY, N. H., AND JASUDASIN, F. (1927). "The Experimental Transmission of S. spindalis to the Indian Water Buffalo," *Indian Jl. Med. Res.*, Vol. 14, No. 3, pp. 701-706.

FAUST, E. C. (1919). "Notes on South African Cercariae," *Jl. Parasit.*, Vol. 5, pp. 164-175, 1 pl.

FAUST, E. C. (1920 *a*). "Criteria for the Differentiation of Schistosome Larvae," *Jl. Parasit.*, Vol. 6, pp. 192-194.

FAUST, E. C. (1920 *b*). "A Survey of Cawston's Species of South African Cercariae," *Parasitology*, Vol. 12, pp. 211-216.

FAUST, E. C. (1921 *a*). "Notes on South African Larval Trematodes," *Jl. Parasit.*, Vol. 8, No. 1, pp. 11-21. 13 figs.

FAUST, E. C. (1921 *b*). "The Present State of the Schistosome Problem," *China Med. Jl.*, Vol. 35, pp. 405-410.

FAUST, E. C. (1921 *c*). "Recent Advances in Parasitology," *Trans. Amer. Micr. Soc.*, Vol. 40, pp. 75-88.

FAUST, E. C. (1926). "Further Observations on South African Larval Trematodes," *Parasit.*, Vol. 18, No. 1, pp. 101-127.

FAUST, E. C. (1927). "The Possible Presence of Male Schistosomes alone in Experimental and Natural Infections," *Jl. Parasit.*, Vol. 14, No. 1, pp. 72-63.

FAUST, E. C., AND MELENEY, H. E. (1923 *a*). "Studies on Schistosomiasis japonica: Morphology, Biology, and Life-History of the Causative Organism, *Schistosoma japonicum* (Katsurada)," *Jl. Trop. Med. and Hyg.*, Vol. 26, pp. 66-69.

FRANCA, C. (1925). "Observations sur la bilharziose," *Bull. Soc. Portugaise des Sci. Nat.*, Vol. 10, No. 5, pp. 63-77.

HASLE, G. (1928). "La bilharziose intestinale sur les hauts Plateaux à Madagascar," *Bull. Soc. Path. Exot.*, Vol. 21, No. 5, pp. 380-382.

HOUGHTON (1923). "Schistosomiasis of the Far East (*Schistosoma japonicum*)," in Byam and Archibald's *Practice of Medicine in the Tropics*, Vol. 3, pp. 1773-1788.

IBRAHIM, A. (1927). "The Problem of Bilharziasis in Egypt," *Jl. State Med.*, Vol. 35, No. 12, pp. 702-708.

JOYEUX, C. (1924). "Les trematodes sanguicoles," *Ann. de Parasit.*, Vol. 2, pp. 100-101.

JOYEUX (1927). "Precis de Médecine coloniale." (Masson & Cie, Paris.)

KHALIL, M. (1922 *a*). "The Morphology of the Cercariae of *Schistosomum mansomi* from *Planorbis boissyi* of Egypt," *Proc. Roy. Soc. Med.*, Vol. 15, pp. 27-34.

KHALIL, M. (1922 *b*). "Observations on the Effect of Tartar Emetic on the Eggs and Miracidia of *Bilharzia haematobia*," *Proc. Roy. Soc. Med.*, Vol. 15. (Sec. "Trop. Dis. and Parasit," pp. 13-15.)

KHALIL, M. (1922 *c*). "On the Susceptibility of the Egg Masses of Planorbis to Drying, Chemical Fertilizers, etc., and its Bearing on the Control of Bilharzia Disease," *Jl. Trop. Med. and Hyg.*, Vol. 25, No. , pp. 67-70.

KHALIL, M. (1927). "The Eradication of Bilharziasis: A Successful Attempt in an Endemic Area," *Lancet*, Dec. 10, p. 1235.

LAMBERT, R. A., AND HOFFMAN, W. A. (1928). "Studies on Schistosomiasis in Porto Rico," *Porto Rico Rev. Public Health and Trop. Med.*, Vol. 3, No. 11, pp. 458-459.

LAMPE, P. H. J. (1927). "The Development of *Schistosoma mansoni*," *Proc. Royal Soc. Med.*, Vol. 20, No. 9, pp. 1510-1516.

LEESE, A. S. (1911). "Bilharziosis in the Camel," *Jl. Trop. Vet. Soc.*, Vol. 6, No. 3, pp. 263-264.

LEESE, A. S. (1927). "One-Humped Camel in Health and in Disease," pp. (Stamford, Lincolnshire.)

LEGER, M. (1928). "Au sujet de la note de G. Haslé sur la bilharziose intestinale à Madagascar," *Bull. Soc. Path. Exot.*, Vol. 21, No. 6, pp. 435-436.

LEIPER, R. T. (1911). "Some Variations in the Character of the Spine in Eggs of *Schistosomum haematobium*," *Jl. Trop. Med. and Hyg.*, Vol. 14, No. 8, pp. 120-121.

LEIPER, R. T. (1915). "Report on the Results of the Bilharzia Mission of Egypt. I. Transmission. II. Prevention and Eradication. III. Development." *Jl. Roy. Army Med. Corps*, Vol. 25, pp. 1-25, 147-192, 253-267.

LEIPER, R. T. (1916). "Report on the Results of the Bilharzia Mission to Egypt. IV. Egyptian Mollusca," *Jl. Roy. Army Med. Crops*, Vol. 27, pp. 171-190.

LEIPER, R. T. (1918). "Report on the Results of the Bilharzia Mission in Egypt. V. Adults and Ova," *Jl. Roy. Army Med. Corps*, Vol. 30, pp. 235-260.

LEIPER, R. T. (1924). "Present-day Teachings on Helminthology in Relation to Public Health," *Brit. Med. Jl.*, July 19th, pp. 110-115.

LEIPER, R. T. (1925). Discussion of Blacklock's (1925), pp. 420-421.

LEIPER, R. T. (1928). "The Occurrence in Cyprus of *Bullinus contortus*. in the Endemic Area of *Schistosoma haematobium*," *Jl. Helm.*, Vol. 6, No. 2, pp. 117-120.

LEIPER, R. T., AND ATKINSON, E. L. (1915). "Observations on the Spread of Asiatic Schistosomiasis; including 'Note on *Katayama nosophora*,'" by G. C. Robson, *Brit. Med. Jl.*, No. 2822, pp. 201-203.

LISTON, W. G., AND SOPARKAR, M. B. (1918). "Bilharziosis among Animals in India: The Life-Cycle of *Schistosoma spindalis*," *Indian Jl. Med. Res.*, Vol. 5, pp. 567-569.

LUTZ, A. (1919). "O *Schistosomum mansoni* e a Schistosomiasis segundo observacoes feitas no Brazil," *Mem. Inst. Oswaldo Cruz*, Vol. 11, pp. 121-155.

MAHFEEZ, A. H. (1927). "A Case of *Schistosoma bovis* in Man," *Egyptian Med. Rev.*, pp. 301-306 (in Arabic). (Reviewed *Trop. Dis. Bull.*, Vol. 25, No. 12.)

MELENEY, H. E., AND FAUST, E. C. (1923). "The Intermediate Host of *Schistosoma japonicum* in China," *Proc. Soc. Biol. Med.*, Vol. 20, pp. 216-218.

MEYAGAWA, Y. (1913). "Ueber den Wanderungsweg des *Schistosomum japonicum* durch Vermittlung des Lymphgefossystem des Wirtes," *Centralbl. f. Bakt.* 1 *Abt. Orig.*, Vol. 68, No. 2, pp. 204-206.

MILTON, F. (1919). "Schistosomiasis in India," *Indian Med. Gaz.*, Vol. 54, No. 10, pp. 368-370.

MILLER, H. M. (1926). "Comparative Studies on Furcocercous Cercariae," *Illinois Biol. Monographs*, Vol. 10, No. 3, pp. 265-370.

NICOLL, W. (1922). "Recent Progress in our Knowledge of Parasitic Worms and their Relation to the Public Health," *Parasit.*, Vol. 14, pp. 378-401.

PEAKE, E. C. (1912). "Additional Notes on the Egg of *Schistosomum japonicum*," *China Med. Jl.*, Vol. 26, No. 6, pp. 350-352. (Reviewed by R.T.L. in *Trop. Dis. Bull.*, Vol. 2, No. 4.)

PORTER, A. (1920). "The Experimental Determination of the Vertebrate Hosts of some South African Cercariae from the Mollucs *Physopsis africana* and *Limnaea natalensis*," *Med. Jl. S. Africa*, Vol. 15, pp. 128-133.

PORTER, A. (1920 *a*). "The Invertebrate (Molluscan) Hosts of *Schistosoma mansoni* and *Fasciola hepatica* in South Africa," *Med. Jl. S. Africa*, Vol. 16, pp. 75-76.

PORTER, A. (1921). "The Life-Histories of some Trematodes occurring in South Africa," *S. Afr. Jl. Sci.*, Vol. 18, pp. 156-163.

PORTER, A. (1926). "Notes on the Structure and Life-History of a variety of *Schistosoma spindalis* Montgomery observed in South Africa," *S. Afr. Jl. Sc.*, Vol. 23, pp. 661-666.

ROBERTSON, A. R. (1916). "Case Reports from the Army Medical Services. I. Bilharziasis," *Canadian Med. Assoc. Jl.*, Vol. 6, No. 10, pp. 913-914.

SEVERINGHANS, A. E. (1928). "Sex Studies on *Schistosoma japonicum*," *Quart. Jl. Microscop. Sci.*, Vol. 71, Pt. 4, N.S. No. 284, pp. 653-702.

SKRJABIN, K. I. (1913). "*Schistosomum turkestanum*, nov. sp., ein neuer Parasit des Rindes aus Russisch-Turkestan," *Zeitschr. Infektionskrankh. Haustiere*, Vol. 13, pp. 457-463.

SOPARKAR, M. B. (1921). "The Cercariae of *Schistosoma spindalis* (Montgomery)," *Ind. Jl. Med. Res.*, Vol. 9, pp. 1-22.

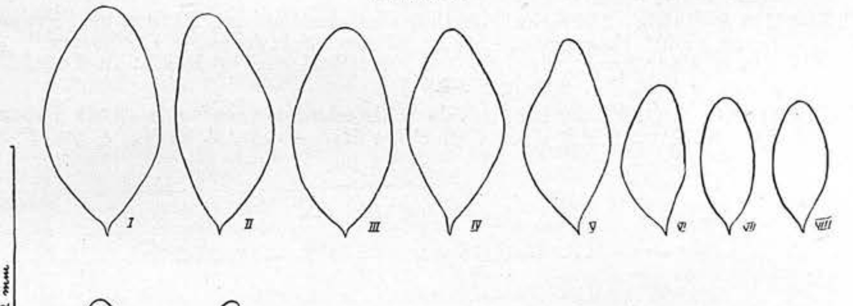
STILES, CH. W., AND HASSALL, A. (1902). "Index-Catalogue of Medical and Veterinary Zoology," *Bull. Bur. Anim. Indus.*, No. 39.

STILES, CH. W., AND HASSALL, A. (1908). "Index-Catalogue of Medical and Veterinary Zoology: Trematoda and Tramatode Diseases," *Bull. Hyg. Lab.*, No. 37.

TSUCHIYA (1913). "Clinical, Pathological-Anatomical, Pathogenic, Prophylactic, and Therapeutic Study of the *Schistosomiasis japonica*," *Jl. Tokyo Med. Assoc.*, Vol. 27, No. 10. (Reviewed by R.T.L. in *Trop. Dis. Bull.*, Vol. 2, No. 8, pp. 406-407.)

WALKIERS, J. (1928). "Cinq cas de Schistosomias a oeufs depourvus d'eperon dans le Haut-Uelé," *Ann. Soc. Belge Med. Trop.*, T. 8, No. 1, pp. 21-22.

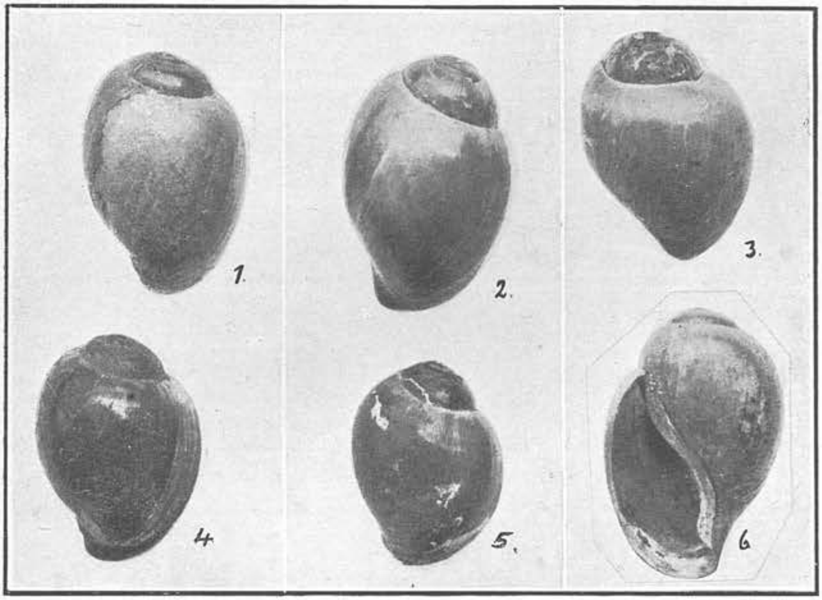
PLATE 1.



FIGS. I TO VIII.—*Schistosoma haematobia* ova from the urine of a human in Pretoria, Transvaal.

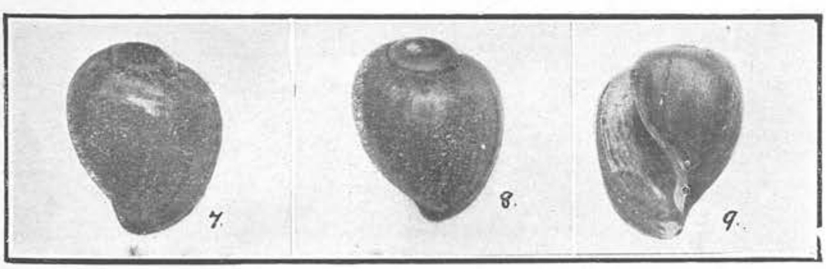
FIGS. 1 TO 7.—*Schistosoma mattheei* ova from the faeces of sheep from Humansdorp, Cape Province.

FIGS. 1 TO 6.

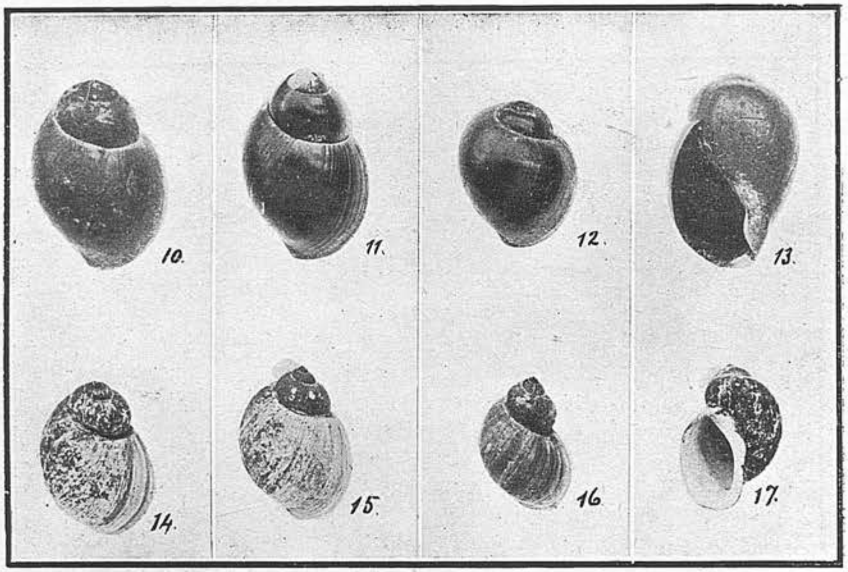


Specimens of *Physopsis africana*, var. *globosa* (Morelet), from Humansdorp, Cape Province. Magn. $1\frac{3}{4}\times$.

FIGS. 7 TO 9.



Specimens of *Physopsis conicum* from the Pretoria District, Transvaal. Magn. $1\frac{3}{4}\times$.



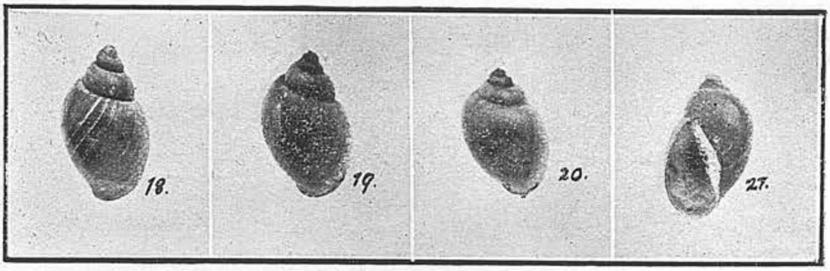
FIGS. 10 TO 13.

Specimens of *Physopsis africana* (Krauss) from Natal. Note the difference in the shape of Nos. 10 and 11 and Nos. 12 and 13. Magn. $1\frac{1}{2}\times$.

FIGS. 14 TO 17.

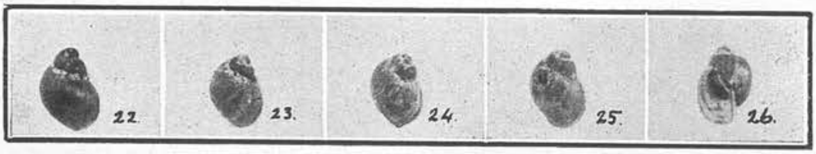
These are said to be specimens of *Bulinus tropicus* (Krauss). From the Pretoria District, Transvaal. Magn. $1\frac{1}{2}\times$. (See Figs. 32 and 33.)

FIGS. 18 TO 21.



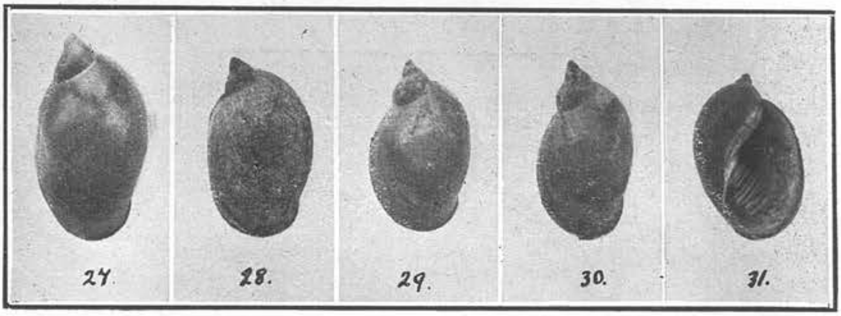
A fresh-water snail from the field cornetcy of Goudini, Worcester Cape Province. This species was found infected with cercariae of *Fasciola* and *Paramphistomum*. Mag. $1\frac{1}{2}\times$.

FIGS. 22 TO 26.



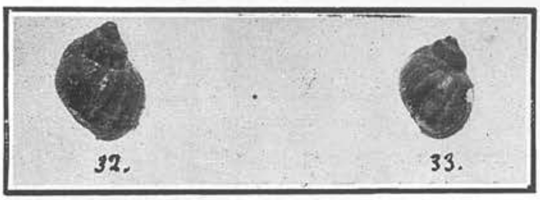
Immature (?) specimens of *Bulinus* from a vlei near Humansdorp. Mag. 1½×.

FIGS. 27 TO 31.



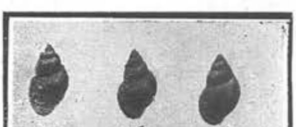
Specimens of *Lymnaea natalensis* (Krauss) from Humansdorp. Magn. 1½×.

FIGS. 32 AND 33.



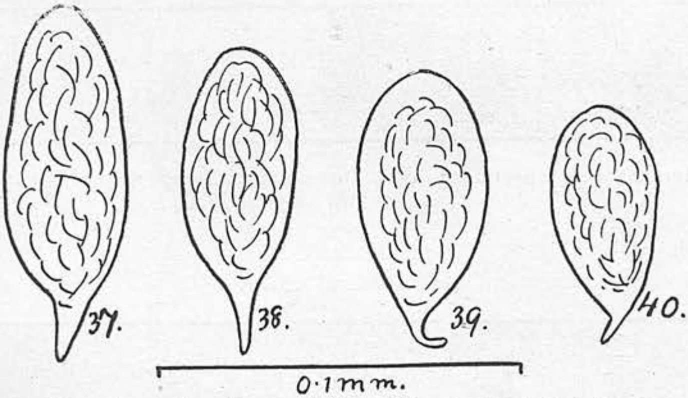
Specimens of *Bulinus* identified as *B. schackoi* (Jickeli), which species is, according to Cawston (1928), identical with *B. tropicus*, *B. natalensis*, *B. craveni*, and *B. sericinus*.

FIGS. 34 TO 36.



Specimens of *Lymnaea truncatula* (Müller), a common intermediate host of *Fasciola hepatica* in the Western Province, Cape. Magn. 1½×.

FIGS. 37 TO 40.



Eggs from the uterus of *S. mattheei*, which had been subjected to tartar emetic *in vivo*.

FIG. 41.

A specimen of *Fasciola hepatica* from the gall-bladder of a sheep treated with carbon tetrachloride. Note the degeneration of the posterior three-quarters of the fluke.

Article No. 3.

15th Annual Report of the Director of Veterinary Services, Union of South Africa. October, 1929.

Two Species of *Haemonchus* Cobb, 1898, Parasitizing the Camel in the Cape Province.

By P. L. LE ROUX, B.Sc. (Edin.), M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

RECENTLY the writer had the opportunity of examining specimens of *Haemonchus* collected from the abomasum of a camel (*Camelus dromedarius*) destroyed at this Institution on arrival from Vryburg, Cape Province. This camel had run for some years with cattle on the farm Armoedsvlakte owned by the Division of Veterinary Services.

The microscopic examination of the few males collected revealed the presence of two species of *Haemonchus* (*H. longistipes* and *H. contortus*).

As *H. contortus* has not previously been recorded from this host, the specimens were examined closely, but could not be differentiated from members of this species collected from cattle and sheep. The spicules were identical with those of the type species of this genus as is evident from Table I.

The larger females of *H. contortus*, owing to the presence of a rather small linguiform process not uncommonly met with in specimens from cattle, could not be too readily differentiated from the specimens of *H. longistipes* of approximately the same size. The most important measurements of these specimens of *H. contortus* are given in Table II.

The measurements (Tables III and IV) of the specimens of *H. longistipes*, Railliet and Henry, 1909, collected agree with the findings of Boulenger (1921).

I have nothing to add to Boulenger's description except that in the specimens examined by me, the ventral lip of the cloaca ends in an appendage (Fig. 10) and is not as bluntly rounded off as figured by him (1921, Fig. 2a).

As this appendage is frequently bent dorsally, it is quite readily missed unless the lip is viewed laterally.

The short dorsal lip of the cloaca is, as in *Haemonchus contortus* (Fig. 2), supported by two rays.

TABLE I.

The Measurements (in microns) of the spicules of H. contortus *from the camel compared with those of* H. contortus *from sheep and from cattle.*

Authors	Ransom, 1911.	Dykmans, 1921.	Travassos, 1921.	Veglia, 1916.	Le Roux.		
Locality	North America.	North America.	South America.	South Africa.	South Africa.		
Origin	Sheep and Cattle.	Cattle.	Sheep and Cattle.	Sheep and Cattle.	Camel.	Sheep.	Cattle.
Length of Spicules	300–500	400–430	390–500	460–470	494–504	462–506	462–495
Barb-like projection from the posterior extremity of spicule — Right	40	28–32	28–40	40	49–58	40–60	48–60
Barb-like projection from the posterior extremity of spicule — Left	20	14–17	14–20	20	23–25	20–28	26 30

TABLE II.

The Measurements (in millimetres) of six females of H. contortus *from the camel.*

Length of worm	16·0	17·5	17·8	18·0	18·0	23·0
Maximum diameter of body	0·29	0·31	0·33	0·37	0·329	0·349
Length of oesophagus	1·50	1·60	1·63	1·56	1·60	1·66
Maximum diameter of oesophagus	0·104	0·120	0·112	0·120	0·112	0·108
Anterior extremity to excretory pore	0·33	0·32	0·33	0·316	0·32	0·34
Anterior extremity to cervical papillae	0·40	0·40	0·40	0·38	0·42	0·42
Vulva to anus	2·50	3·10	3·10	3·28	2·90	3·72
Anus to tip of tail	0·48	0·56	0·54	0·66	0·60	0·82
Length of linguiform process	0·14	0·16	0·12	0·20	0·14	0·20
Measurements of eggs in utero	0·070×0·038	0·068×0·038	0·072×0·038	0·076×0·040	0·075×0·040	0·078×0·042

TABLE III.

The Chief Measurements (in millimetres) of five females of Haemonchus longistipes, *Railliet and Henry,* 1909, *from the camel* (Camelus dromedarius) *in the Cape Province, compared with those as recorded by Railliet and Henry* (1909) *and Boulenger* (1921).

Authors	Railliet and Henry, 1909.	Boulenger, 1921.	Le Roux.				
Locality	Africa and India.	India.	Cape Province, South Africa.				
Length of worm	26–29	23–35	28·5	29·0	31·5	31·5	32·0
Maximum width	—	0·45–0·65	0·595	0·595	0·627	0·680	0·653
Length of oesophagus	—	1·60–2·10	1·810	1·800	1·940	1·940	1·940
Maximum width of oesophagus	—	—	0·168	0·156	0·160	0·176	0·183
Anterior extremity of excretory pore	—	—	0·281	0·400	0·356	0·324	0·356
Anterior extremity to cervical papillae	—	0·39–0·53	0·399	0·518	0·448	0·432	0·443
Vulva to tip of tail	—	4·5 –6·8	6·0	5·75	6·5	6·0	6·0
Anus to tip of tail	—	0·47–0·58	0·454	0·432	0·540	0·486	0·486
Caudal papillae to tip of tail	—	—	0·108	0·130	0·160	0·160	0·140

TABLE IV.

The Chief Measurements (in millimetres) of six males of Haemonchus longistipes, *Railliet and Henry*, 1909, *from the camel* (Camelus dromedarius) *in the Cape Province, compared with those recorded by Railliet and Henry, and Boulenger.*

Authors	Railliet and Henry, 1909.	Boulenger, 1921.	Le Roux.					
Locality	Africa and India.	India.	Cape Province, South Africa.					
Length of worms	20–21	18–25	20	21	22	22	23	23
Maximum width of worms	—	0·4	0·400	0·389	0·378	0·378	0·389	0·450
Anterior extremity to excretory pore	—	—	0·432	0·432	0·380	0·540	0·486	0·464
Anterior extremity to cervical papillae	—	0·39–0·53	0·580	0·580	0·514	0·680	0·670	0·660
Length of oesophagus	—	1·6 –2·1	1·746	·1649	1·804	1·649	1·649	1·552
Maximum width of oesophagus	—	—	0·156	0·164	0·121	0·156	0·160	0·132
Length of spicules	0·625	0·60–0·65	0·66	0·63	0·62	0·62	0·62	0·66
Barb to extremity of right spicule	—	0·09–0·10	0·092	0·094	0·090	0·996	0·090	0·098
Barb to extremity of left spicule	—	0·038–0·04	0·043	0·043	0·038	0·042	0·040	0·044
Length of common stem of dorsal ray	—	—	0·213	0·194	0·183	0·183	0·168	0·168
Length of the two main brabches of dorsal ray	—	—	0·066	0·066	0·078	0·086	0·092	0·096
Length of the gubernaculum	—	0·3 –0·33	0·324	0·324	0·324	0·326	0·324	0·324
Width of the gubernaculum	—	—	0·119	0·119	0·119	0·119	0·119	0·119

REFERENCES.

BOULENGER, C. L. (1921). " On some Nematode Parasites of the Camel in India," *Parasitology*, Vol. 12, No. 4, pp. 311-314.

DIKMANS, G. (1921). " Preliminary Notes on Parasites found in Ruminants at Municipal Abattoirs, Baton Rouge, Louisiana," *Louisiana Bulletin* No. 183, Louisiana State University.

RAILLIET, A., AND HENRY, A. (1909). " Sur la Classification des *Strongylidae: Metastrongylinae*," *C.R. Soc. Biol.*, Vol. 66, p. 85.

RANSOM, B. H. (1911). " The Nematodes Parasitic in the Alimentary Tract of Cattle, Sheep, and other Ruminants," *U.S. Dept. Agr., Bur. Animal Ind.*, Bull. No. 127, pp. 49-54.

TRAVASSOS, L. (1921). " Contributions à l'étude de la Fauna helminthologique du Brésil XIII Essai. Monographique sur la famille des *Trichostrongylidae*, Leiper, 1909," *Mem. Inst. Oswaldo Cruz*, Vol. 12, pp. 35-40.

VEGLIA, F. (1915). " The Anatomy and Life-history of the *Haemonchus contortus* (Rud.)," *Third and Fourth Reports, Dir. Vet. Res.*, Pretoria.

YORKE, W., AND MAPLESTONE, P. A. (1926). " The Nematode Parasites of Vertebrates," pp. 122-123. (J. A. Churchill, London.)

ADDENDA.

EXPLANATION OF FIGURES.

(PAGES 445–450.)

ARTICLE 26.

Haemonchus contortus (Rud.).

FIG. 1.—Lateral view of the posterior extremity of an immature male showing the right lateral lobe and a ventral lobe not hitherto described for *Haemonchus*, and the genital cone with pointed appendage.

FIG. 2.—Dorsal view of the ventral lobe to the copulatory bursa.

FIG. 3.—Ventral view of a genital cone of a mature male.

FIG. 4.—Ventral lobe of a mature male. Tip of the spicules showing.

FIG. 5.—Mature female without linguiform process or cuticular bosses. From a sheep.

FIG. 6.—Linguiform process poorly developed and slightly lateral to the vulva. From the camel.

FIG. 7.—Posterior extremity of a mature female. From a sheep.

FIG. 8.—Linguiform process poorly developed and to the side of the vulva. From a calf.

FIG. 9.—Linguiform process fairly well developed and with the vulva on its lateral surface. From a calf infected with larvae from sheep's droppings.

Haemonchus longistipes Railliet & Henry, 1909.

FIG. 10.—Ventral view of the genital cone and the ventral lobe of the bursa.

FIG. 11.—Copulatory bursa in two parts.

FIG. 12.—Posterior extremity of the female.

FIG. 13.—Lateral aspect of the tip of the right spicule.

FIG. 14.—Lateral view of the left spicule and ventral view of the right spicule.

FIG. 15.—Poorly developed linguiform process situated laterally to vulva.

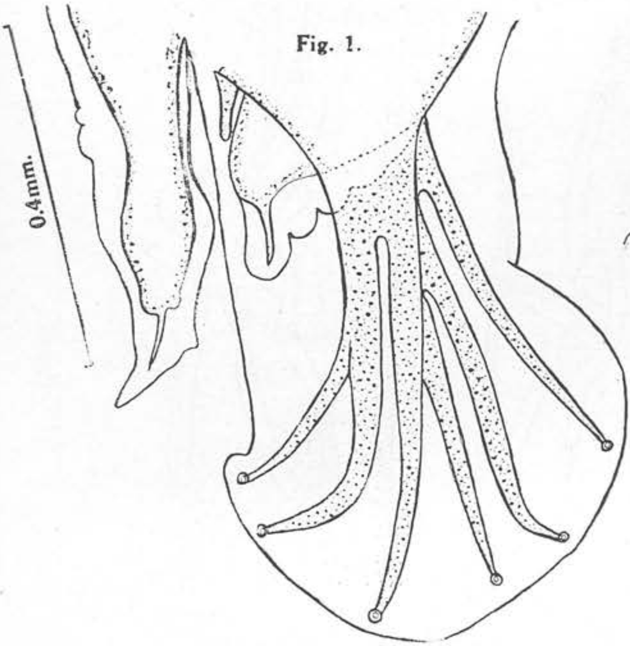


Fig. 1.

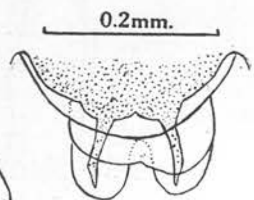


Fig. 2.

Fig. 3.

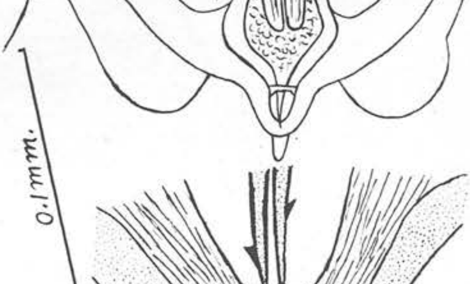


Fig. 4.

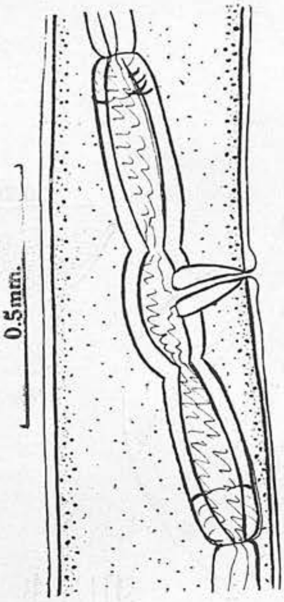


Fig. 5.

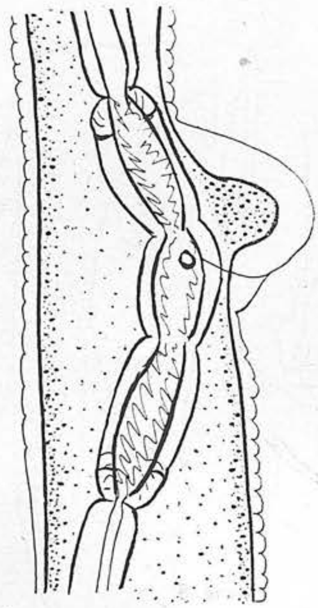


Fig. 6.

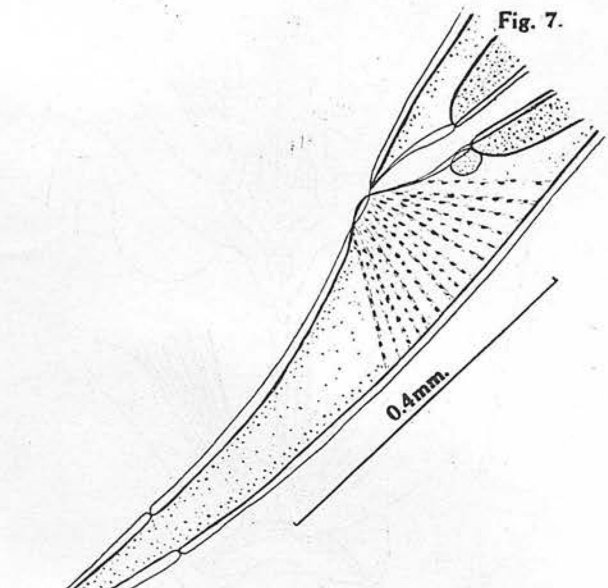


Fig. 7.

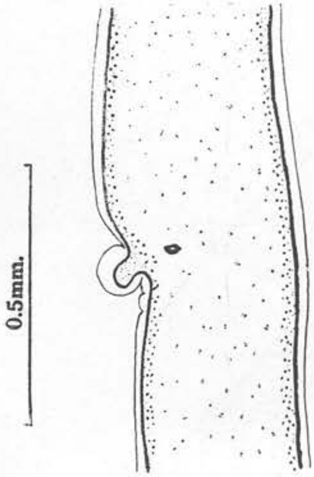


Fig. 8.

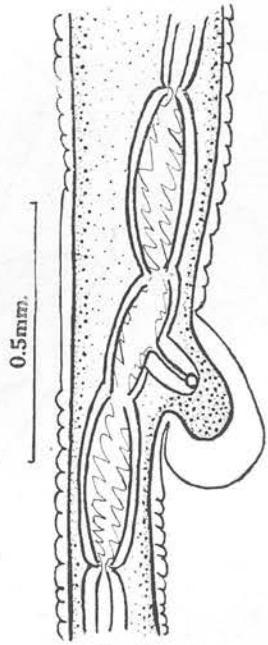


Fig. 9.

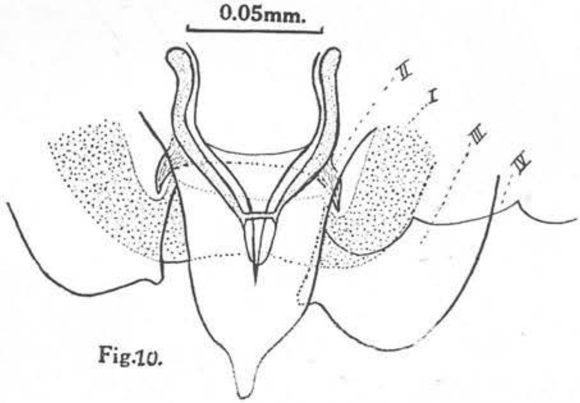


Fig. 10.

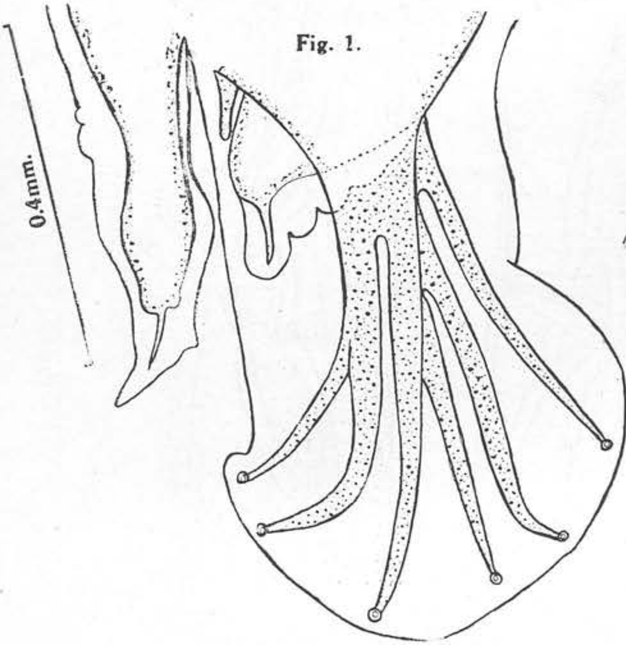


Fig. 1.

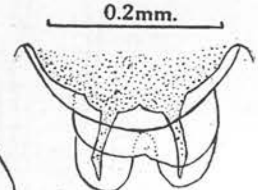


Fig. 2.

Fig. 3.

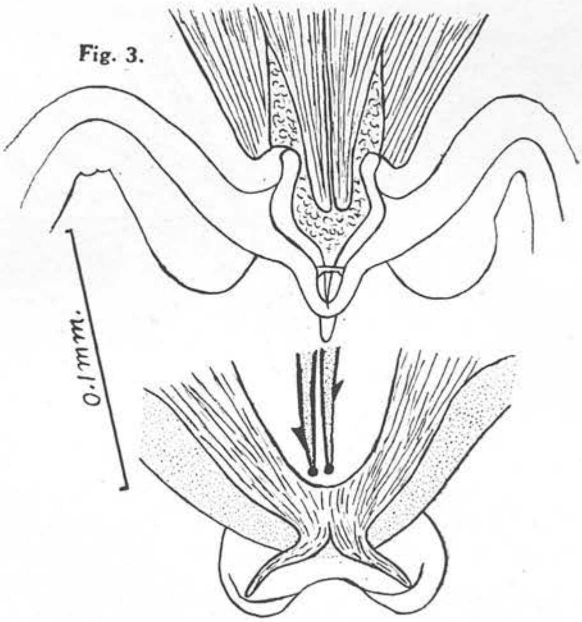


Fig. 4.

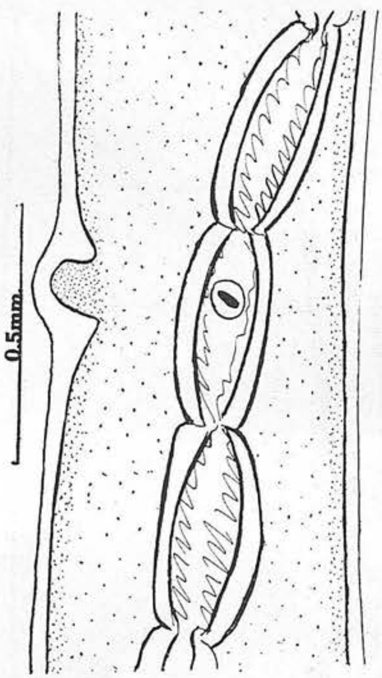


Fig.15.

Article No. 4.

15th Annual Report of the Director of Veterinary Services, Union of South Africa. October, 1929.

A Preliminary Report on Three New Members of the Genus *Haemonchus*, Cobb, 1898, from Antelopes in South Africa.

By P. L. LE ROUX, B.Sc. (Edin.), M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

About three years ago Mr. D. T. Mitchell, M.R.C.V.S., Sub-Director of Veterinary Services, presented me with some nematodes collected from the *abomasi* of two eland (*Taurotragus oryx*, Pall.) shot in the Drakensberg National Game Reserve, Natal.

The examination of the material, preserved in 10 per cent. formalin, revealed the presence of two species of nematodes, *Ostertagia circumcincta* and a species of *Haemonchus* new to science. For this species the name *Haemonchus mitchelli*, sp. nov., in honour of the donor, is designated.

On my transfer to the Onderstepoort Veterinary Research Laboratory, I had the opportunity of examining three lots of *Haemonchus contortus* (Rud.) contained in the helminthological collection and labelled as having been collected from the *abomasi* of the Cape koodoo (*Strepsiceros strepsiceros* Pall.), the blue wildebeest (*Gorgon taurinus* Burch.), and the African buffalo (*Synceros caffer*, Sparrm.).

The examination of the spicules of the specimens decolorized in lacto-phenol, proved them not to be members of the type species as shown on the labels.

For the species from the abomasum of the Cape koodoo, I designate the name *Haemonchus vegliai*, sp. nov., in honour of Dr. Francesco Veglia, whose work on the morphology and life-history of *Haemonchus contortus* is well known to all interested in Nematology.

The specimens from the blue wildebeest and the African buffalo were identical, judging from the spicules. For this species the name *Haemonchus bedfordi* in honour of the donor, Mr. G. A. H. Bedford, Research Officer in Entomology, is designated.

As type host of this species, I select the blue wildebeest, from which the specimens collected by Mr. Bedford were most excellently preserved in glycerine alcohol.

The specimens from the African buffalo were collected in Zululand by Dr. H. H. Curson while investigating Nagana there. This material was not well preserved. The measurements given for *H. bedfordi* are of specimens taken from blue wildebeest shot in the Waterberg district, Northern Transvaal.

Most of the material from the koodoo was not well preserved and the measurements given below cannot be taken as absolutely characteristic for the species.

A detailed description of each individual species is held over. The three species are typical members of the genus *Haemonchus*, Cobb, 1898. The differences which allow of their identification are given below, and their chief measurements are tabulated in Tables I and II.

It must be pointed out that only the most perfectly preserved specimens were examined and that twelve males and twelve females of each species were measured.

Differentiation of the species.

Here, as in the genus *Trichostrongylus*, Looss, 1905, the examination of males is essential for the identification of a species.

The males of the different species are readily distinguished from each other by the characters of their spicules.

The tips of the spicules do not only bear characteristic barbs, but these barbs are situated at constant levels, varying with the different species. In the case of *H. vegliai*, the left spicule is furnished with two barbs (Figures 21 and 22). The lobes and their rays comprising the *copulatory bursa* show slight variations in the different species.

Variations are also evident in the genital cones of various species. Of all the characters referred to, those of the spicules alone are of such a nature as to allow of the differentiation of the species.

The females could to some degree be recognized by the characters of their *linguiform processes*. As in the type species, the *linguiform process* is liable to considerable variation within specimens from the same host.

In *H. mitchelli* the *linguiform process* is a fairly stout and well-developed appendage situated in front of the genital opening and partly or wholly overlapping it. In the majority of specimens the vulva with the vagina slightly evaginating is located at the right commissure, formed by the *linguiform process* and the body.

In *H. bedfordi* the linguiform process shows still more anomalies. In some specimens there are well-developed *pre-vulvar* and *post-vulvular processes* (*linguiform processes*). In others there are only post-vulvular processes, and these were often at a considerable distance from the genital opening.

In a third group there were no *linguiform processes present*.

In all three groups one or two *lateral cuticular swellings* may be absent or present in the region of the vulva. These swellings are associated with sexual functions, and in specimens observed in copula they were gripped by the lateral lobes of the copulatory bursa.

H. vegliai yielded variations as well. In most specimens the *linguiform process* was replaced by a mere swelling as figured.

The apparent anomalies of the vulvular linguiform process as met with in *Haemonchus contortus* has been commented on by Veglia (1915) and Dikmans (1921). Judging from the observations of Veglia and Dikmans on the type species and my personal findings, just given, it is evident that the character of this process, in any one known species, is not so constant as to accept it as of a specific generic character.

Baylis and Daubney (1922) differentiated the species *Haemonchus cervinus* of the spotted deer (*Cervus axis*) from *Haemonchus contortus* because "the vulva is slightly prominent, but possesses no overhanging anterior lip such as is found in *H. contortus*." Specimens of *H. contortus* without an overhanging linguiform process are by no means uncommon from both sheep and cattle in South Africa.

The species *Haemonchus cervinus* Baylis and Daubney (1922), should most probably be considered a *species inquirendae*. An examination of the spicules (if present) of the damaged male is desired if *H. cervinus* Baylis and Daubney, 1922, is to be retained as a valid member of the genus.

Curson (1928), recording *Haemonchus contortus* (Rud.) from the ox, sheep, goat, buffalo and wildebeest in Zululand, comments on the fact that although the wild ruminants were heavily infected, they showed no ill effects such as are manifested by domestic stock similarly infested.

Curson's record of *H. contortus* from the buffalo and the wildebeest is incorrect, as is proved by the specimens collected by him and deposited in the helminthological collection at Onderstepoort.

Haemonchus contortus (Rud.) of Curson 1928 now becomes a synonym of *Haemonchus bedfordi*, sp. nov.

Although the two old eland bulls shot by Mr. Mitchell were very heavily infected with the two species mentioned elsewhere, they were in excellent condition. Their age and the good grazing probably accounted for the absence of lesions attributable to *Haemonchosis*.

TABLE I.

Measurements (in millimetres) of the males of Haemonchus contortus, H. mitchelli, H. vegliai *and* H. bedfordi.

Species	*H. contortus.*	*H. mitchelli*, sp. nov.	*H. vegliai*, sp. nov.	*H. bedfordi*, sp. nov.
Hosts	Sheep, goat, cattle, camel.	*Taurotragus oryx* Pall.	*Strepsiceros strepsiceros* Pall.	*Synceros caffer* Sparrm., *Gorgon taurinus* Burch.
Length of body	15–18	10·5 –14	9·5 –11	9·8 –11·5
Maximum breadth of body	0·27	0·27 –0·33	0·24 –0·3	0·23 –0·27
Anterior end to excretory pore	0·276	0·20 –0·30	0·20 –0·25	0·21 –0·32
Anterior end to cervical papillae	0·32 –0·44	0·28 –0·43	0·30 –0·40	0·33 –0·40
Maximum width of oesophagus	0·15	0·12 –0·13	0·11 –0·13	0·09 –0·14
Length of oesophagus	1·50	1·25 –1·42	1·10 –1·60	1·10 –1·30
Length of spicules	0·460–0·506	0·50 –0·54	0·44 –0·48	0·40 –0·46
Distance of barbs from tip of spicules: Right	0·040–0·060	0·07 –0·086	0·06 –0·07	0·09 –0·11
Distance of barbs from tip of spicules: Left	0·020–0·030	0·034–0·040	(i) 0·040–0·050 (ii) 0·028–0·035	0·044–0·053
Length of gubernaculum	0·20 –0·25	0·26 –0·37	0·28 –0·35	0·25 –0·32

TABLE II.

Measurements (in millimetres) of females of H. contortus, H. mitchelli, H. vegliai *and* H. bedfordi.

Species	*H. contortus.*	*H. mitchelli*, sp. nov.	*H. vegliai*, sp. nov.	*H. bedfordi*, sp. nov.
Length of Body	16–24	18·5–21·0	14·5–20	14·5–19·5
Maximum breadth of body	0·29–0·40	0·40–0·46	0·34–0·42	0·33–0·38
Length of oesophagus	1·50–1·70	1·60–1·73	1·20–1·70	1·20–1·49
Maximum width of oesophagus	0·11–0·13	0·17–0·20	0·17–0·21	0·12–0·17
Anterior extremity of excretory pore	0·27–0·34	0·20–0·29	0·21–0·30	0·25–0·31
Anterior extremity to cervical papillae	0·32–0·42	0·29–0·38	0·34–0·49	0·29–0·53
Vulva to posterior extremity	3·50–5·10	3·20–3·57	3·00–3·80	2·90–3·70
Anus to posterior extremity	0·40–0·63	0·29–0·38	0·31–0·59	0·33–0·42

REFERENCES.

BAYLIS, H. A., AND DAUBNEY, R. (1922.) "Report on the Parasitic Nematodes in the Collection of the Zoological Survey of India." *Memoirs Indian Museum*, Vol. 7, No. 4.

BOULENGER, C. L. (1921). "On some Nematode Parasites of the Camel in India," *Parasitology*, Vol. 12, No. 4, pp. 311-314.

CURSON, H. H. (1928). "Metazoan Parasites from Zululand." *S. Afr. Jl. Nat. Hist.*, Vol. 6, pp. 181-187.

DIKMANS, G. (1921). "Preliminary Notes on Parasites found in Ruminants at Municipal Abattoirs, Baton Rouge, Louisiana," *Louisiana Bulletin* No. 183, Louisiana State University.

LE ROUX, P. L. (1929). "Two Species of *Haemonchus* Cobb, 1898. Parasitizing the Camel in the Cape Province." (See this Report, pp. 439-450.)

RAILLET, A., AND HENRY, A. (1909). "Sur la Classification des *Strongylidae: Metastrongylinae*," *C.R. Soc. Biol.*, Vol. 66, p. 85.

RANSOM, B. H. (1911). "The Nematodes Parasitic in the Alimentary Tract of Cattle, Sheep, and other Ruminants," *U.S. Dept. Agr., Bur. Animal Ind.*, Bull. No. 127, pp. 49-54.

TRAVASSOS, L. (1921). "Contributions à l'étude de la Fauna helminthologique du Brésil XIII Essai. Monographique sur la famille des *Trichostrongylidae*, Leiper, 1909," *Mem. Inst. Oswaldo Cruz*, Vol. 12, pp. 35/40.

VEGLIA, F. (1915). "The Anatomy and Life-history of the *Haemonchus contortus* (Rud.)," *Third and Fourth Reports, Dir. Vet. Res.*, Pretoria.

YORKE, W., AND MAPLESTONE, P. A. (1926). "The Nematode Parasites of Vertebraes," pp. 122-123. (J. A. Churchill, London.)

ADDENDA.

EXPLANATION OF FIGURES.

(PAGES 457–463.)

ARTICLE 27.

FIG. 1.—Female with linguiform process posterior to the vulva. From *Gorgon taurinus*. (*Haemonchus bedfordi*, sp. nov.)

FIG. 2.—Female with linguiform process posterior and lateral to the vulva. Note the prominent cuticular swelling. From *Gorgon taurinus*. (*Haemonchus bedfordi*, sp. nov.)

FIG. 3.—Note absence of linguiform process and cuticular swelling. From *Gorgon taurinus*. (*Haemonchus bedfordi*, sp. nov.)

FIG. 4.—Note the presence of pre- and post-vulvular linguiform processes and a well developed cuticular swelling. From *Gorgon taurinus*. (*Haemonchus bedfordi*, sp. nov.)

FIGS. 5 and 6.—Females from *Synceros caffer* Sparrm. (*Haemonchus bedfordi*, sp. nov.)

FIG. 7.—Posterior extremity of a female from *Gorgon taurinus*. (*Haemonchus bedfordi*, sp. nov.)

FIG. 8.—Copulatory bursa of a male from *Gorgon taurinus*. (*Haemonchus bedfordi*, sp. nov.)

FIG. 9.—Ventral view of the genital cone, etc. (*Haemonchus bedfordi*, sp. nov.)

FIG. 10.—Posterior extremity of a female from *Synceros caffer*. (*Haemonchus bedfordi*, sp. nov.)

FIG. 11.—Dorsal ray of the copulatory bursa. (*Haemonchus mitchelli*, sp. nov.)

FIG. 12.—Copulatory bursa. (*Haemonchus mitchelli*, sp. nov.)

FIG. 13.—Posterior extremity of the female. (*Haemonchus mitchelli*, sp. nov.)

FIGS. 14, 15, and 16.—Linguiform processes in different specimens. (*Haemonchus mitchelli*, sp. nov.)

FIG. 17.—Genital cone and the ventral lobe of the bursa. (*Haemonchus mitchelli*, sp. nov.)

FIG. 18.—No linguiform process, but a cuticular swelling present. (*Haemonchus vegliai*, sp. nov.)

FIG. 19.—Posterior extremity of the female. (*Haemonchus vegliai*, sp. nov.)

FIG. 20.—The copulatory bursa. (*Haemonchus vegliai*, sp. nov.)

FIG. 21.—Lateral and ventral views of the left spicule. (*Haemonchus vegliai*, sp. ncv.)

FIG. 22.—Lateral and ventral views of the right spicule. (*Haemonchus vegliai*, sp. nov.)

FIG. 23.—Lateral view of the spicules. (*Haemonchus mitchelli*, sp. nov.)

FIG. 24.—Lateral view of the spicules, etc. (*Haemonchus bedfordi*, sp. nov.)

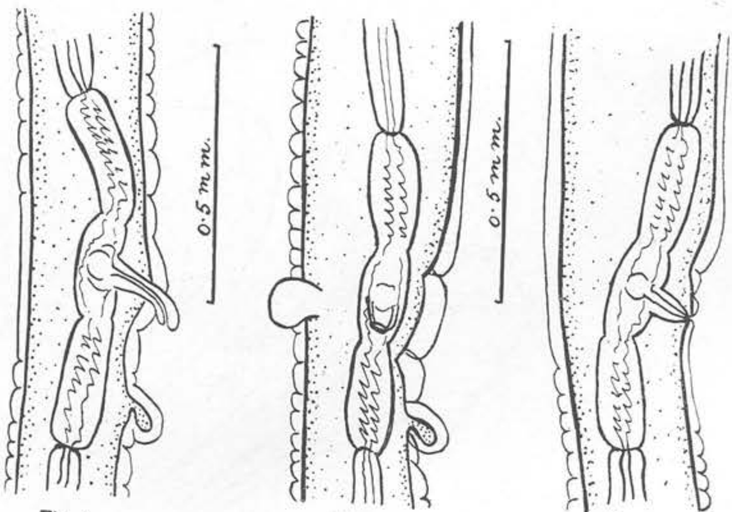


Fig. 1. Fig. 2. Fig. 3.

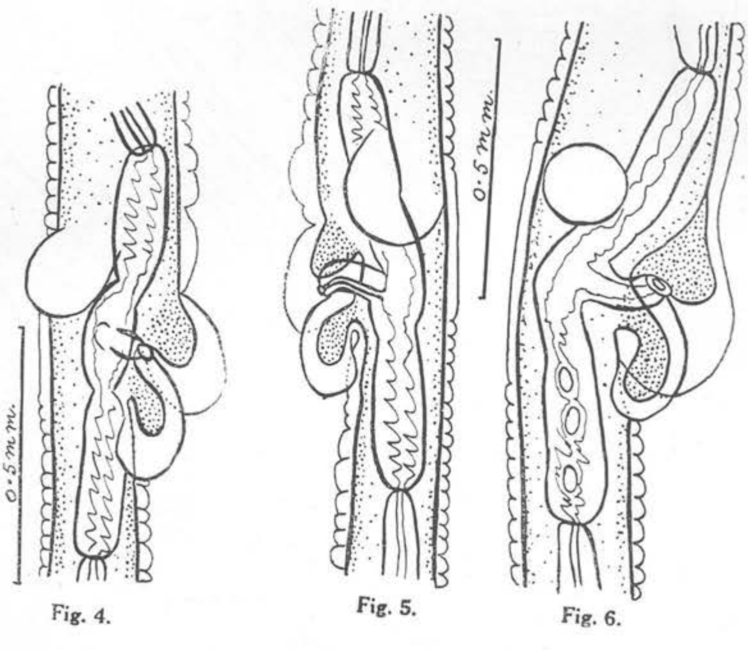


Fig. 4. Fig. 5. Fig. 6.

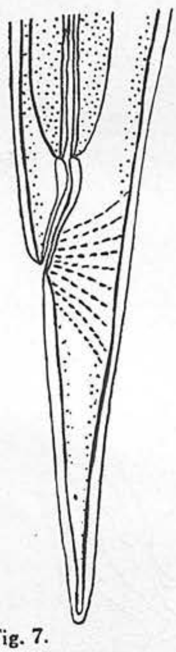


Fig. 7.

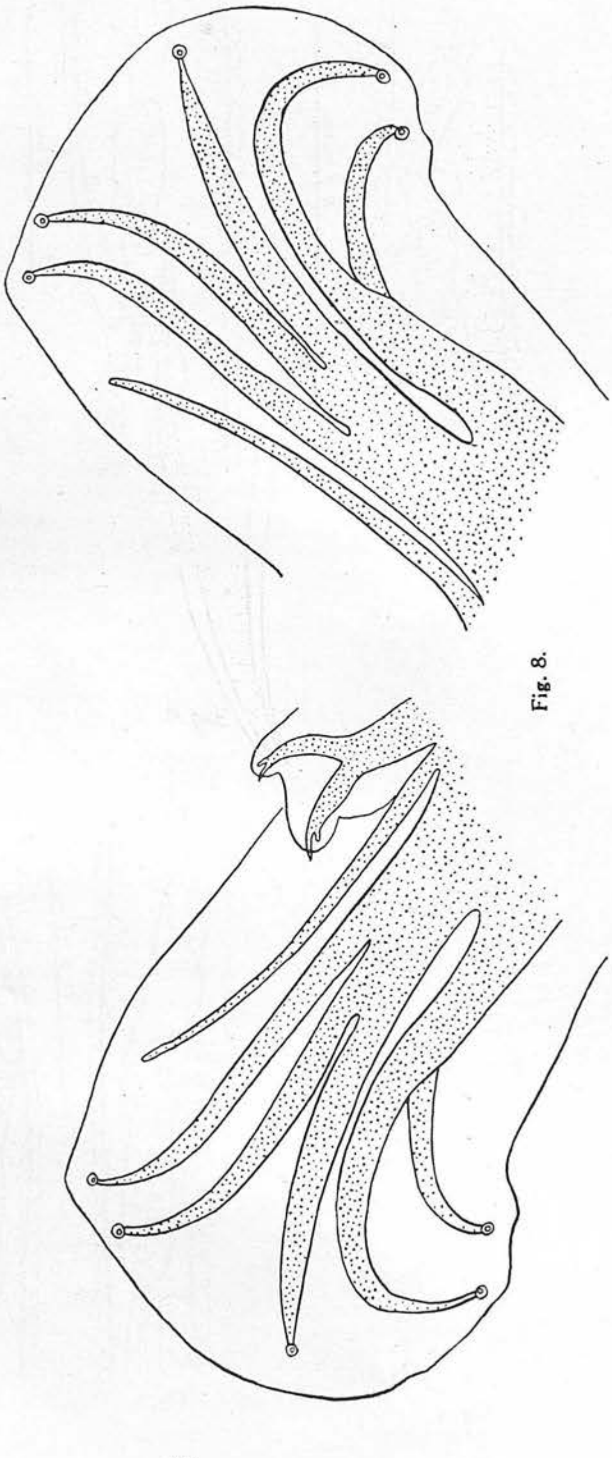


Fig. 8.

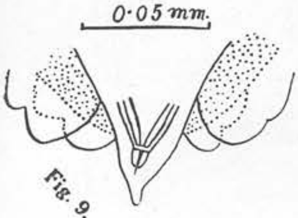


Fig. 9.

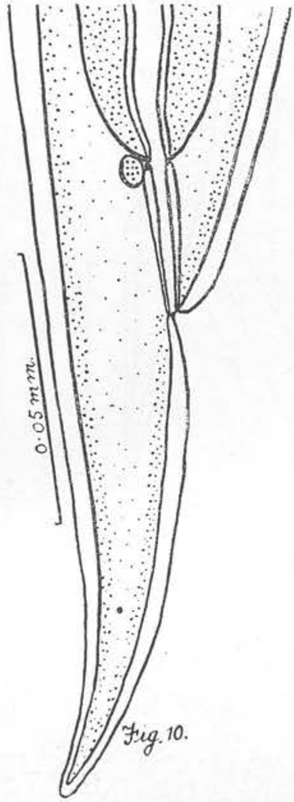


Fig. 10.

Fig.11.

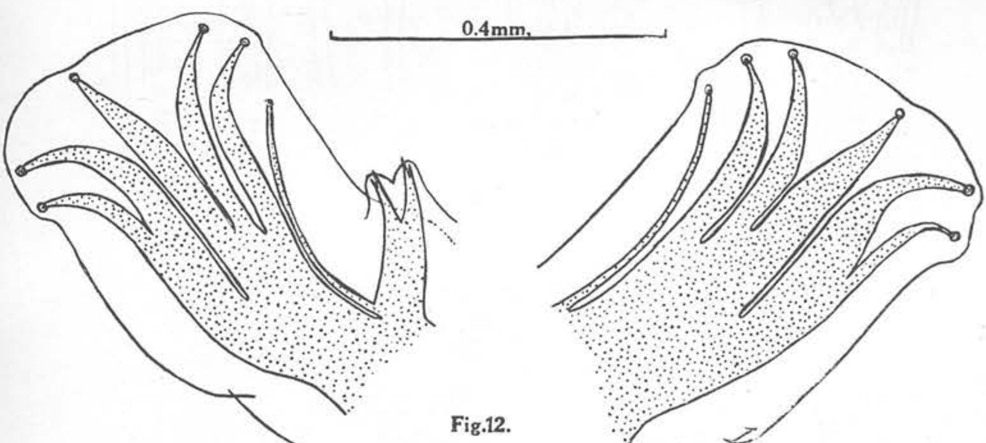


Fig.12.

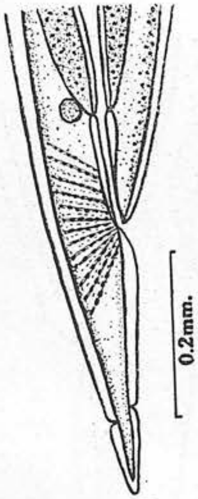


Fig.13.

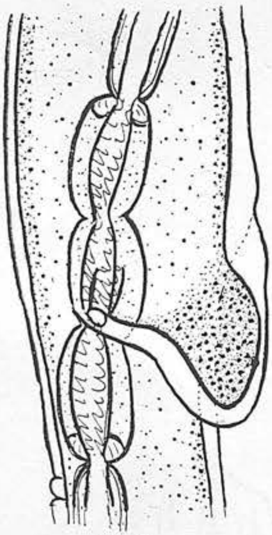


Fig.14.

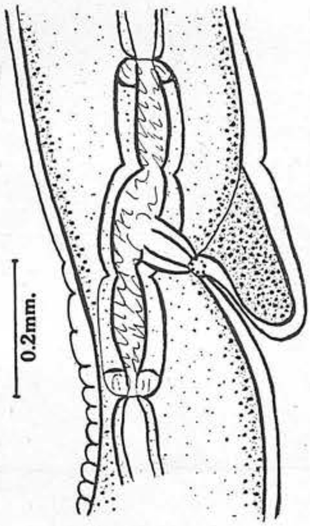


Fig.15.

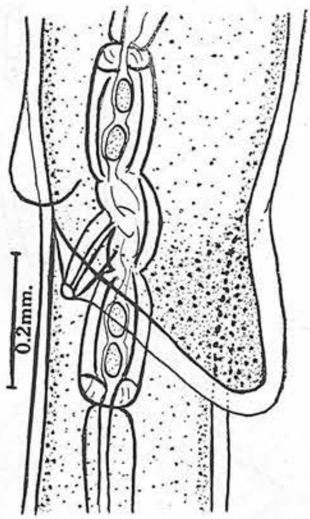


Fig.16.

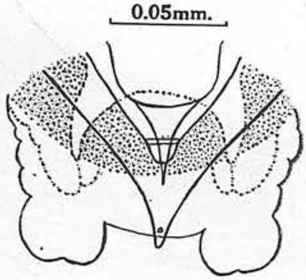


Fig.17.

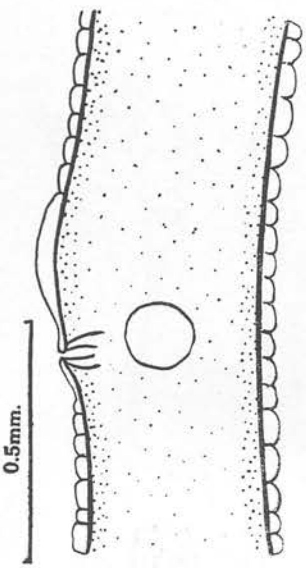


Fig.18.

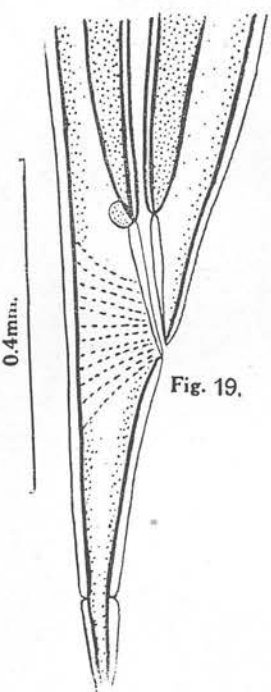


Fig. 19.

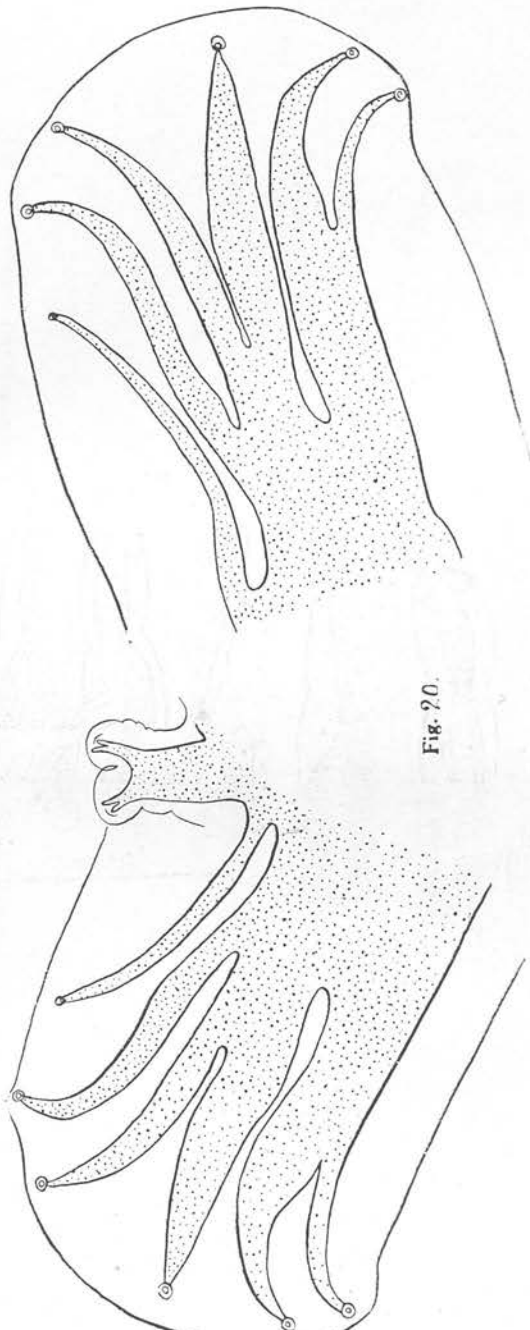
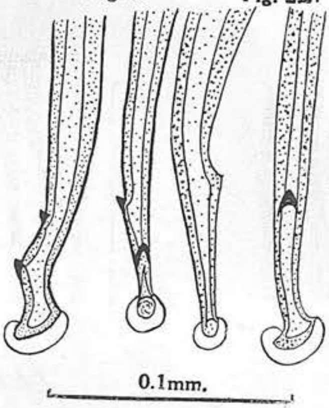


Fig. 20.

Fig. 21. Fig. 22.



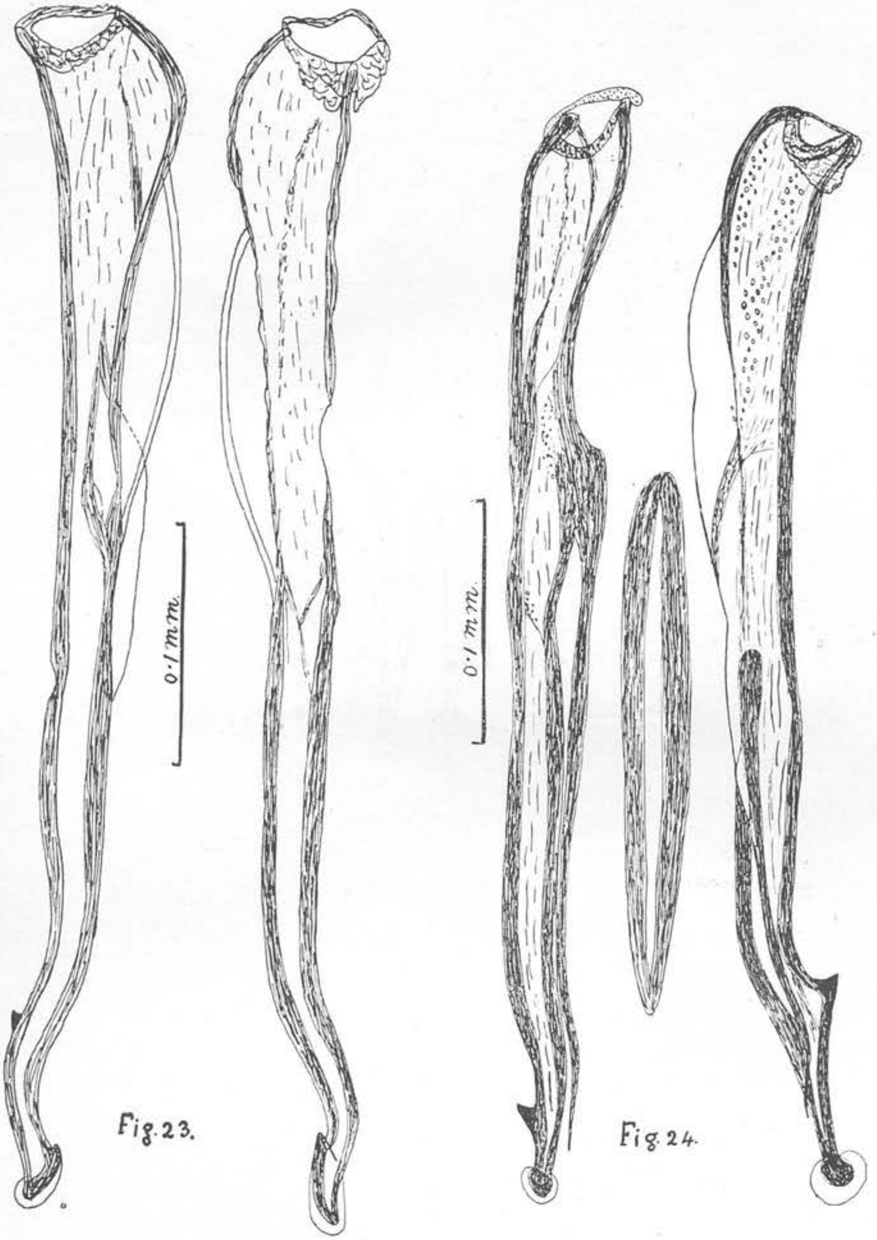


Fig. 23.

Fig. 24.

Article No. 5.

15th Annual Report of the Director of Veterinary Services, Union of South Africa. October, 1929.

On an Oesophagostome *(Oesophagostomum susannae,* sp. nov.) from the Springhare *(Pedetes caffra),* together with Remarks on closely related Species.

By P. L. LE ROUX, B.Sc. (Edin.), M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

INTRODUCTION.

IN 1927 the writer collected four nematodes from four haemorrhagic submucosal cysts in the caecum of a Springhare shot at the Nooitgedacht Veterinary Research Laboratory, Ermelo, Eastern Transvaal. The search of the lumen of the alimentary tract for helminths yielded a solitary female of the genus *Trichocephalus*, located in the caecum.

The microscopic examination of the specimens from the cysts proved them to be sexually immature adult members (two males and two females) of the genus *Oesophagostomum* Molin, 1861. The structure of the buccal capsule and the character of the oesophageal funnel showed that they were members of a species closely related to three or possibly four of the known oesophagostomes. In Table I the chief measurements of the new species will be found given with the available measurements of the related forms.

Before dealing with the morphology of *O. susannae*, the related species will be considered briefly as regards hosts and geographical distribution.

Oesophagostomum apiostomum (Willach, 1891), Railliet and Henry, 1905, was originally described as *Sclerostoma apiostomum* from nodules in the intestine of *Macacus cynomolgus*. Weinberg collected several specimens of this species from *M. cynomolgus* and *M. sinicus*. It is on this material that Railliet and Henry base their description of *O. apiostomum*.

Leiper (1911) declares *O. brumpti*, Railliet and Henry, 1905, to be synonymous with *O. apiostomum*, which he records:

- (*a*) from the great intestine of monkeys in Uganda;
- (*b*) from cysts in the wall of the colon of *M. sinicus*; and
- (*c*) as passed by a native patient of Dr. Andrew Foy at Ibi, Northern Nigeria.

Leiper (1913) once more declares *O. brumpti* as synonymous with *O. apiostomum*, which is this time recorded from inmates of the Zungeru Gaol, Northern Nigeria. His drawing (Fig. 15, p. 274) of the anterior extremity of the worm appears without the recurved oesophageal teeth characteristic of the members of the subgenus *Conoweberia* Ihle, 1922. Judging from the measurements given by Leiper (1911 and 1913), I am inclined to agree with Railliet and Henry (Brumpt 1927, p. 674), and Ihle, 1922, that Leiper was dealing with a species or species other than *O. apiostomum* or *O. brumpti*. A re-examination of Leiper's material seems desirable.

Lane and Low (1923, 1899), tabulating the chief measurements of the Strongylidae rarely infesting man, has the names *O. apiostomum* and *O. stephanostomum* interchanged. They have adopted *O. brumpti* as a synonym of *O. apiostomum*, for whom only Africa is cited as locality. Walker (1913) records *O. apiostomum* as of common occurrence in the Philippines. Ihle (1922) gives the most detailed description existing for *O. apiostomum*, which is recorded for the first time in the wall of the intestine of an orang-outan.

Until Leiper's *O. apiostomum* is definitely proved to be identical with that of Willach, the distribution of this species remains confined to Asiatic monkeys.

Oesophagostomum brumpti Railliet and Henry, 1905, was originally described from material collected by Brumpt from nodules in the intestinal wall of a negro in the vicinity of the River Omo. Smit (1919) records this species from a monkey in Java. His description of the parasite is so incomplete that the identity is not proved. He gives the length of the spicules as 1300 μ, which seems to indicate the possibility of the parasite being *O. apiostomum*.

Henry and Joyeux (1920) record *O. brumpti* as a parasite of man, *Troglodytes niger*, *Cercopithecus callitrichus*, *C. patas*, and *Papio sphinx* in Upper French Guinea.

Joyeux (Brumpt 1922) saw specimens of this species passed by natives after the administration of thymol.

Oesophagostomum xeri Ortlepp 1922 was obtained from the caecum and caecal wall of the bristly ground-squirrel (*Geosciurus capensis*, syn. *Xerus setosus*), from South Africa, where this host is found living in close association with the springhare, as it not infrequently is.

Oesophagostomum susannae can be readily distinguished from the above-mentioned species by the possession of the characteristic short, thick, and dorsally tilted, blunt tail of the female.

THE MORPHOLOGY OF "OESOPHAGOSTOMUM SUSANNAE," Sp. Nov.

The worms extracted by puncturing the cysts were of a slightly dirty white colour. The body fluid of the cephalic extremity, in the immediate neighbourhood of the oesophagus, was tinted slightly red, as is often observed in members of the genus *Trichonema*—inhabitants of the large intestines of equidae. No curving of the cephalic extremity, a characteristic of oesophagostomes furnished with lateral cervical alae, occurred in these specimens on preservation in hot glycerine alcohol. Neither was this observed in sexually mature specimens collected for me by my colleague, Mr. I. P. Marais, and preserved in cold 10 per cent. formalin.

Both males and females showed slight attenuation towards the extremities. This attenuation was in the female more noticeable at the cephalic end, whereas in the male it was more marked at the posterior extremity.

The anterior extremity inflated to form a prominent *mouth collar* and limited posteriorly by a conspicuously deep *cephalic groove*, is ornamented with the usual six *circum-oral papillae*. In most of the specimens preserved in formalin the mouth collar was not so markedly inflated and hence had a less deep *cephalic groove*. In these specimens the *sub-dorsal* and the *sub-ventral cephalic* papillae showed up prominently, often projecting 33 μ beyond the anterior surface of the mouth collar. These papillae appear with distinctly constricted off, lanceolated tips measuring approximately 5 μ in length with a diameter of 3 μ. In specimens with markedly inflated mouth collars, the papillae appear slightly shorter owing to the pushing forward of the cuticle enveloping the cores of the papillae.

The *lateral cephalic papillae* appear as broad flat circular papillae on the antero-lateral surface of the mouth collar. The papillae are, in the cases with inflated mouth collars, situated in a depression of the cuticle. In other cases they project slightly beyond the surface of the cuticle.

The *cervical vesicle*, well marked in the sexually immature adults from the submucosal cysts and preserved in hot glycerine alcohol, extends from the cephalic groove to the level of the cervical papillae. In the specimens obtained from the lumen of the caecum and preserved in cold 10 per cent. aqueous solution of formalin, the *cervical vesicle* was much less prominent. In a few cases it appeared practically non-existent. In these latter, folds, suggesting escape of fluid from the vesicle, were numerous. This observation is recorded to warn workers aganist attaching too much significance to the degree of development of such easily distorted structures as the *mouth collar*, *cephalic groove*, and *cervical vesicle*. The nature of these is too readily affected by different methods of preservation to be of any specific generic significance. Thornton (1924), in his description of *Oesophagostomum oldi*, Goodey 1924, notes that the specimens examined by him at Liverpool had but slightly developed cephalic vesicles, with three to four lesser circular grooves, not recorded by Goodey, anterior to the cervical groove. As the worms were excellently preserved, Thornton did not regard their presence as due to shrinking of the cuticle. Authors unfortunately do not always state how the specimens examined by them were orginally preserved.

The degree of inflation of the cervical vesicle is in the species *O. radiatum* influenced by the activity of the parasite at the time of collection. In specimens with cephalic extremities embedded in crypts in the mucosa the vesicles were much more inflated than in those found free in the lumen of the gut. This inflation in the case of *O. radiatum* is an adaptation for anchoring itself in mucosal crypts, while it feeds on blood (?) or body tissues (?) acted on by secretions from the cephalic and oesophageal glands. The lumens of the older crypts were almost invariably filled with a coagulated dirty brown mass—material similar to that lining the ulcers caused by *Triodontophorus tenuicollis* in the right dorsal colon of equines.

Ventrally and on a level with the *cervical nerve ganglion* the cuticle of the cervical vesicle is indented to form the *ventral cervical groove*, in the posterior wall of which the *excretory pore* is localized.

The *cervical papillae* are prominent and in general disposition not unlike those of the type species of the genus. In a few individuals the free attenuated portion was wholly or partially missing on one or both sides.

The *cephalic*, the *cervical* and the *subventral oesophageal glands* are arranged as described by Goodey (1924) for *O. dentatum*.

The dorsal oesophageal gland opens into the buccal cavity at the summit of a well-developed *dorsal gutter*, a structure hitherto undescribed for oesophagostomes. The species closely related to the one under discussion should be re-examined for this structure, which was found to measure approximately 6-7 μ in height by 5 μ in width.

The *oral aperture* situated centrally on the anterior extremity is guarded by twelve stout, long (20 μ), sharply pointed elements composing the *external leaf crown*.

The buccal cavity is circular with stout, thick, cuticularized wall. Posteriorly the wall tapers to a slightly sharper edge than anteriorly and articulates with the oesophagus, which is anteriorly slightly cuticularized and grooved to receive the cuticularized wall of the buccal capsule. Dorsally the depth of the buccal capsule is 13 μ, whilst ventrally it is 16-17 μ. Medially and anteriorly the wall of the buccal cavity bears a prominent cuticularized fold, projecting medially and slightly anteriorly. At this point the lumen of the cavity is reduced to 33 μ, while the internal diameters at the inlet and the outlet of the capsule are 46 μ and 50 μ respectively.

In some of the specimens examined there was a distinct internal leaf-crown composed of rather minute elements arising from the cuticularized fold referred to above. The apparent absence of an internal leaf-crown in other specimens can only be attributed to the diminutiveness of its elements and the fact that they are obscured by the thick (5-6 μ) wall of the buccal cavity.

The cuticular fold described above is figured also for *O. apiostomum* by Ihle (1922). He does not express an opinion as to its function or its analogy to an interval leaf-crown which he declares seems absent.

For *O. xeri* Ortlepp (1922) there is described an internal leaf-crown of rather small elements.

Posterior to the chitinous fold the surface of the buccal wall is lined by a prominently inflated cuticle.

The buccal capsule leads posteriorly into a deep (36 μ) and wide (30 μ) oesophageal funnel formed by an increase in width and a decrease in thickness of the anterior extremities of the three oesophageal sectors. The cuticular lining of the lumen of the oesophagus and oesophageal funnel, instead of being continued to end in acute teeth projecting into the buccal cavity, is at the posterior border of this structure deflected medially and posteriorly to form a *dorsal* and two *subventral oesophageal teeth*.

The *oesophagus* is club-shaped, with the anterior portion forming the oesophageal funnel markedly dilated as the measurements will indicate. The maximum diameter is attained posteriorly, while the minimum diameter is approximately on a level with the ventral cervical groove.

The union of oesophagus with intestine is guarded by the usual three oesophageal valves.

The cells of the intestine were in sexually mature specimens heavily laden with dark pigment granules. This pigmentation, present throughout the length of the gut, was most pronounced in the anterior portion. It is the presence of this pigment which imparts the dirty grey to deep dark colour to the sexually mature adults. Posteriorly the lumen of the gut appears to have a cuticularized wall.

Male characters.

As the different measurements will be found in Table I, only the remaining characters will be considered. As regards colour, the males are slightly lighter than the females, which are undoubtedly more active feeders.

The *copulatory bursa* closely resembles that described for *O. apiostomum* and *O. xeri*. Variations in the distribution of rays were noticed and are figured. The prebursal papillae, situated about 400 μ from the caudal extremity, were prominent in some individuals, but less well defined in others owing to the longitudinal contraction with the resultant throwing of the cuticle into folds.

A prominent genital cone directed posteriorly and slightly ventrally arises by a broad base from the floor of the copulatory bursa. The *cloaca* communicates with the outside through a transverse ellipsoidal aperture situated subterminally on the dorsal face of the genital cone. Anterior to the anus the dorsal surface is indented by a transverse groove as figured by Goodey (1924) for *O. dentatum*.

The two lateral commissures of the cloacal aperture are each bounded laterally by a genital appendage, differing in shape with the angle from which they are viewed. In a ventral view they appear spherical with a ventrally directed appendage. When viewed laterally the spherical shape is replaced by a triangular one, with the apex of the triangle directed ventrally and guarding the protruding spicules. In the sexually mature males these appendages were best developed, indicating their relation to sexual activity.

The chitinized spicules are alated and of equal length. The alation stops within 66 μ of the free extremities, which terminate in fine turned-up points.

Female characters.

Posteriorly the female shows hardly any attenuation when examined with the unaided eye. On microscopical examination the maximum diameter was found to be reached at a point a little in front of the vulva. From this point the attenuation is rapid until the anus is reached. The tail is short, stout, blunt, and, in most of the specimens examined, tilted dorsally to be at right angles to the long axis of the body. The anus is situated at the posterior ventral angle of the thus formed foot. Near the tip of the tail there are the usually *caudal papillae*, somewhat ill-defined in most specimens.

The vulva is located on the anterior slope and near the summit of a well-marked elevation.

The vagina is of some length and is noteworthy in that it arises from the anterior border of the *pars ejectrix*. This appeared such an unusual phenomenon that two females were dissected with needles under a binocular microscope to verify this. The *pars ejectrix*, with concave anterior curvature and convex posterior curvature, occupies an oblique position in the body. The structure and general disposition of the remaining genitalia is typical as recorded for members of the genus. The posterior extremity in all adult females showed the usual brown cement material adherent.

Acknowledgements.

The writer wishes to express his indebtedness to his colleague, Mr. I. P. Marais, Veterinary Research Officer, for the material collected from the caecum and colon of springhares shot in the western Transvaal while investigating an outbreak of rabies amongst the small wild mammalia in that area.

LITERATURE.

BAYLIS, H. A., and DAUBNEY, R. (1926). "A Synopsis of the Families and Genera of Nematoda," pp. 163-164. (Richard Clay & Sons, Ltd., Bungay, Suffolk.)

DAUBNEY, R. (1924). "Description of a New Nematode, *Oesophagostomum mwanzae*, from the Warthog," *Ann. Mag. Nat. Hist.*, Ser. 9, Vol. 13, No. 77, pp. 542-546.

BRUMPT, E. (1927). "Précis de Parasitologie," pp. 671-674. (Masson & Cie, Paris.)

GOODEY, T. (1924 a). "The Anatomy of *Oesophagostomum dentatum* (Rud.), a Nematode Parasite of the Pig, with Observations on the Structure and Biology of the Free-living Larvae," *Jl. Helminthology*, Vol. 2, No. 1, pp. 1-14.

GOODEY, T. (1924 b). "Oesophagostomes of Goats, Sheep, and Cattle," *Jl. Helminthology*, Vol. 2, No. 3, pp. 97-110.

GOODEY, T. (1924 c). "Some New Members of the genus *Oesophagostomum* from the Roan Antelope and the Wart Hog," *Jl. Helminthology*, Vol. 2, No. 3, pp. 135-148.

GOODEY, T. (1925). "*Oesophagostomum longicandum*, n. sp., from the Pig in New Guinea," *Jl. Helminthology*, Vol. 3, No. 1, pp. 45-50.

HENRY, A., and JOYEUX, CH. (1920). "Contribution à la faune helminthologique de la Haute-Guinée francaise," *Bull. Soc. Path. Exot.*, Vol. 13, pp. 176-182.

HEWLETT, R. T., and DE KORTE, W. C. (1918). "On an Encysted Nematode (*Oesophagostomum stephanostomun*) found in the colon of *Cynocephalus hamadrias* and of *Macacus rhesus*," *Jl. Path. and Bact.*, Vol. 12, pp. 211-213.

IHLE, J. E. W. (1922). "On *Oesophagostomum apiostomum* and some Remarks on the Classification of the Strongylidae," *Bydr. tot de Dierkunde*, Afl. 22, pp. 89-94.

LANE, C., and LOW, G. C. (1923). "Intestinal Infestations other than Ankylostomiasis," in *The Practice of Medicine in the Tropics*, edited by Byam and Archibald, Vol. 3, pp. 1896 and 1899. (Frowde and Hodder & Stoughton, London.)

LEIPER, R. T. (1911). "The Occurrence of *Oesophagostomum apiostomum* as an Intestinal Parasite of Man in Nigeria," *Jl. Trop. Med. and Hyg.*, Vol. 13.

LEIPER, R. T. (1913). "Observations on certain Helminthes of Man," *Trans. Soc. Trop. Med. and Hyg.*, Vol. 6, No. 8, pp. 274 and 276.

LEIPER, R. T. (1926). "Discussion of the Validity of certain Generic Names at present in Use in Medical Helminthology," *Arch. f. Schiffs- u. Tropenhyg.*, Vol. 30, Prt. 9, pp. 484-491.

ORTLEPP, R. J. (1922). "A New Species of *Oesophagostomum* (*O. xeri*, sp. n.), from a Rodent (*Xerus setosus*)." *Proc. Zool. Soc.*, London, June, 1922.

RAILLIET, A., ET HENRY, A. (1910). "Encore un nouveau Sclerostomien (*Oesophagostomum brumpti*, nov. sp.) parasite de l'homme," *C.R. Soc. Biol.*, Vol. 54, pp. 643-645.

RAILLIET, A., ET HENRY, A. (1910). "Etude zoologique de l'oesophagostome de Thomas," *Ann. Trop. Med. and Parasit.*, Vol. 4, No. 1, pp. 89-94, Plate 6.

RANSOM, B. H. (1911). "The Nematodes parasitic in the Alimentary Tract of Cattle, Sheep, and other Ruminants," *U.S.A. Dept. of Agric. Bureau of Animal Ind.*, *Bull.* 127, pp. 40-47.

SMIDT, H. (1906). "Ueber einen neuen, biem Gibbon gefundenen Strongylus (*Strongylus ovatus*, v. Linstow)," *Centralbl. f. Bakt., etc., I Abt. Orig.*, Bd. 41, Heft 6, pp. 646-651.

SMIT, H. J. (1919). "*Oesophagostomum brumpti*," *Nederl. Ind. Bladen voor Diergeneesk. en Dierenteelt*, Deel 31, Afl. 3, pp. 327-329.

THORNTON, H. (1924). "A Review of the Oesophagostomes in the Collection of the Liverpool School of Tropical Medicine," *Ann. Trop. Med. and Parasit.*, Vol. 18, No. 3, pp. 3939-3408.

STILES, C. W., AND HASSALL, A. (1920). "Index Catalogue of Medical and Veterinary Zoology: Round Worms," *U.S. Public Health Service Bulletin* No. 114.

WEINBERG, M. (1906). "Kystes vermineux du gros intestin chez le Chimpanze et les Singes inferieurs," *C.R. Soc. Biol.*, p. 446.

WEINBERG, M. (1909). "Oesophagostomose des Anthropides et des Singes inferieures," *Archives de Parasitologie*, Vol. 13, No. 2, pp. 161-203.

WILLACH, P. (1891). "*Sclerostoma apiostomum*, nov. sp. Ein neuer und gefahrlicher Parasit der Affen," *Archiv. f. Wissensch. und Prak. Thierheilk*, Vol. 71, pp. 340-346.

YORKE, W., AND MAPLESTONE, P. A. (1926). "The Nematode Parasites of Vertebrates," pp. 85-88. (J. & A. Churchill, London.)

TABLE

The Measurements (in Millimetres) of the

Species	*O. brumpti.*	*O. apiostomum.*	*O. apiostomum.*
Hosts	African Negro .	*Macacus sinicus M. cynomolgus*	Man : W. Africa Monkeys : Africa
Habitat	Encysted in wall of caecum and colon	—	Great intestine.
Locality	Omo River....	—	Africa.........
Authors	Rail. and Henry (1905)	Rail. and Henry (1906)	Leiper (1911–1913)
Length: ♂	—	12·5	8
♀	8·5–10·2	14	10
Maximum width: ♂	—	0·4	—
♀	0·295–0·325	0·450	—
Length of oesophagus: ♂	—	0·550–0·60	0·400
♀	0·470–0·500		0·430
Maximum width of oesophagus: ♂	—	—	—
♀	—	—	—
Minimum width of oesophagus: ♂	—	—	—
♀	—	—	—
Maximum width of oesophagus posteriorly: ♂	—	0·165	—
♀	0·150		
Anteiior extremity to cervical papilae: ♂	—	0·320	—
♀	0·320–0·370		
Anterioı extremity to nerve ring: ♂	—	—	0·150
♀	—	—	
Anterior extremity to excretory pore: ♂	—	0·250–0·275	—
♀	—		
Height of buccal capsule: ♂	—	0·020	0·006
♀	0·015		
Internal width of buccal capsule, anteriorly: ♂	—	0·048	0·030
♀	0·035		
Intərnal width of breed capsule, posteriorly: ♂	—	0·065	0·030
♀	0·045		
Leng h of spicules	—	1·250–1·275	0·650
Vulva to caudal extremity	0·350–0·475	0·420	0·350
Vulva to anus	—	0·240	—
Anus to caudal extremity	0·170	0·180	0·200
Ova: Length	—	—	0·063
Ova: Width	—	—	0·027

I.

Various Species mentioned in the Text.

O. stephanostomum	*O. apiostomum.*	*O. xeri.*	*O. susannae.*	*O. susnanae.*
Man and monkeys, Africa	Orang-outan...	*Xerus setosus*...	*Pedetes caffra*..	*Pedetes caffra.*
Wall of the large intestine	—	Lumen and wall of caecum	Wall of caecum	Lumen of caecum and colon.
Africa.........	—	S. Africa......	E. Transvaal...	W. Transvaal.
Lane and Low (1922)	Ihle (1922).....	Ortlepp (1922).	Le Roux (1929)	Le Roux (1929).
6·5–11 8·5–12·5	10 –12·8 11·5–15	12–14 13–16·5	11 13–13·5	11·5–12 13 –17
0·3 —	0·425–0·565 0·530–0·655	0·380 0·510	0·374–0·382 0·425–0·442	0·426–0·474 0·442–0·600
— 0·5	0·615 0·685–0·720	0·600–0·700 0·650–0·825	0·595 0·578	0·537–0·585 0·577–0·585
— —	— —	— —	0·072–0·073 0·071–0·072	0·068–0·073 0·070–0·086
— —	— —	— —	0·052–0·054 0·055–0·059	0·050–0·059 0·059–0·066
—	0·170 0·165–0·170	— —	0·126–0·136 0·125	0·119–0·125 0·128–0·148
0·350	— —	— —	0·390–0·424 0·456–0·458	0·348–0·411 0·430–0·453
0·200	—	—	0·280–0·288	0·275–0·280
0·200	0·262–0·270 0·308	— —	0·271–0·280 0·270–0·272	0·253–0·270 0·260–0·275
—	0·021	—	Dorsal 0·013 Ventral 0·019	Dorsal 0·013 Ventral 0·017
—	Including walls ·060–0·070	— —	0·042 0·046	0·044–0·046 0·047–0·050
—	Including walls 0·078–0·082	— —	0·045 0·050	0·050–0·052 0·050–0·052
0·900–1·080	1·285–1·350	1·290	1·420	1·390–1·420
0·350–0·475	0·410–0·450	—	0·326–0·339	0·350–0·390
—	—	—	0·183–0·186	0·192–0·215
0·170–0·200	0·205–0·210	0·114–0·142	0·156–0·170	0·130–0·180
— —	— —	0·058 0·039	No ova in uterus	0·072 0·047

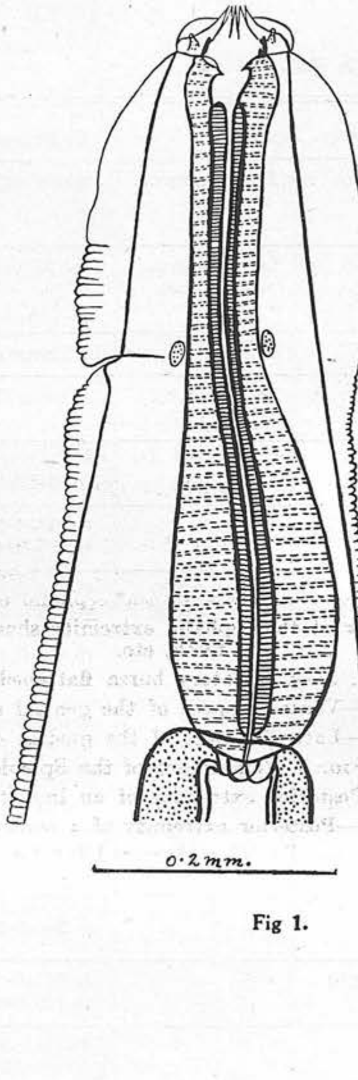


Fig 1.

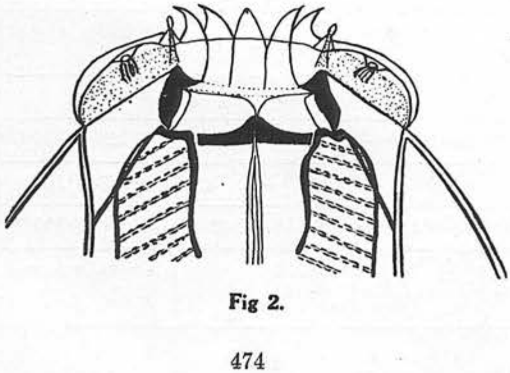


Fig 2.

ADDENDA.

EXPLANATION OF FIGURES.

(PAGES 474–479.)

ARTICLE 28.

FIG. 1.—Cephalic extremity.

FIG. 2.—Dorsal view of the cephalic extremity showing the dorsal gutter, etc.

FIG. 3.—Lateral view of the cephalic extremity.

FIG. 4.—Dorsal view of the cephalic extremity showing the oesophageal teeth, etc.

FIG. 5.—Copulatory bursa flattened out.

FIG. 6.—Ventral aspect of the genital cone, etc.

FIG. 7.—Lateral aspect of the genital cone, etc.

FIG. 8.—Tip of one of the Spicules.

FIG. 9.—Posterior extremity of an immature female.

FIG. 10.—Posterior extremity of a mature female.

FIG. 11.—A portion of a dissected-out female genitalia.

FIG. 12.—Portion of the caecum of a springhare showing submucosal nodules; the one nodule shows a female in section.

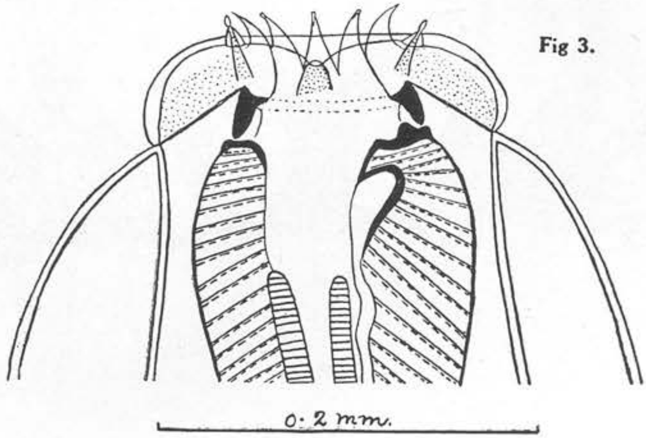


Fig 3.

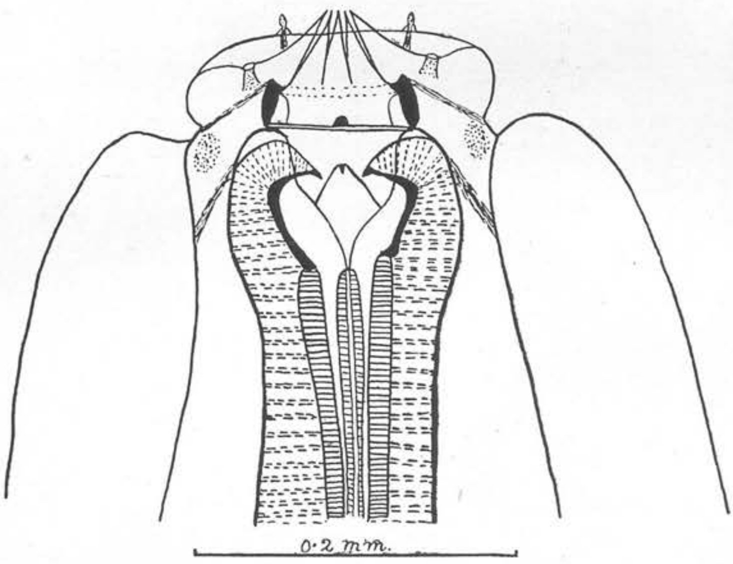


Fig 4.

Dorsal view, showing the dorsal gutter, the oesophageal teeth, etc.

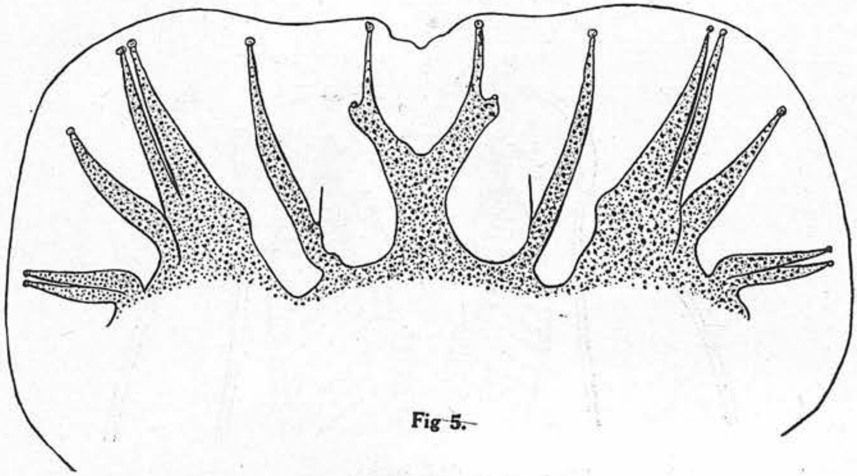


Fig 5.

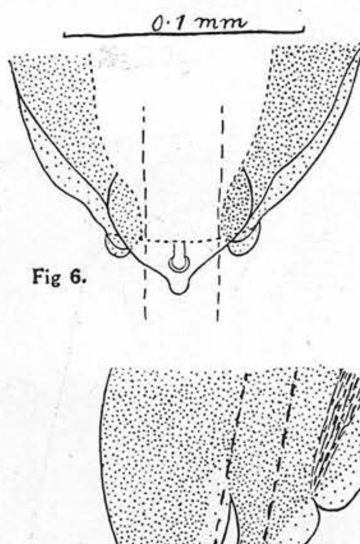


Fig 6.

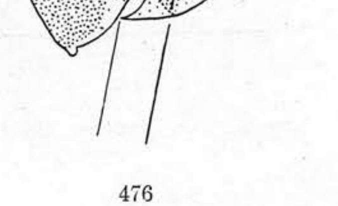


Fig 7.

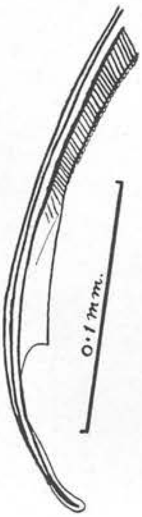


Fig 8.

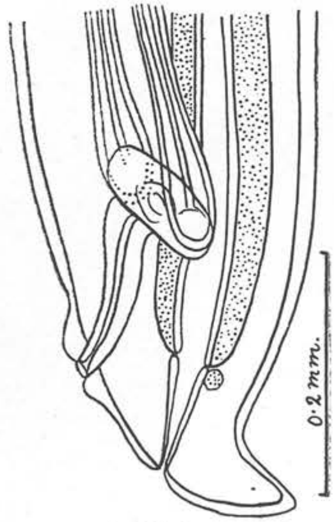


Fig 9.

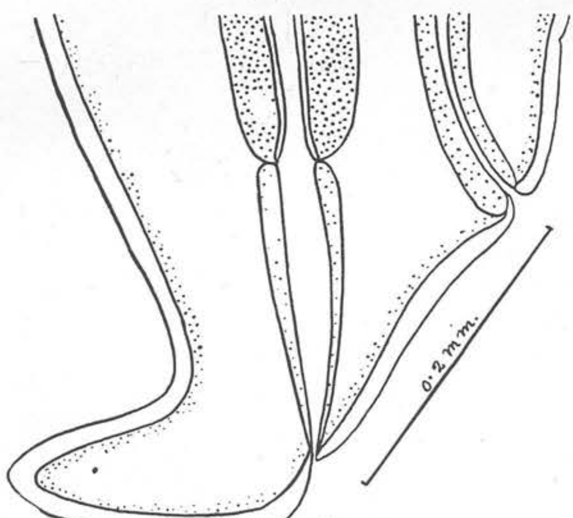


Fig 10.

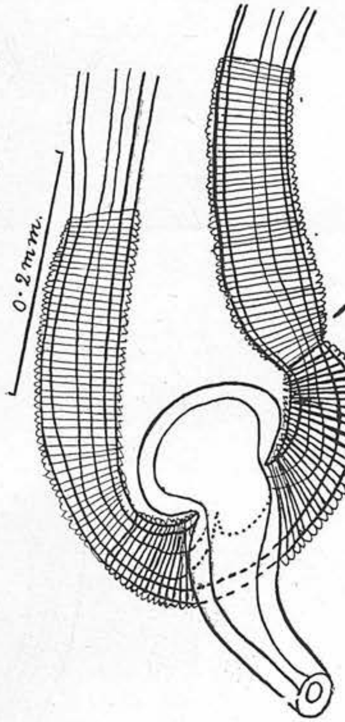


Fig 11.

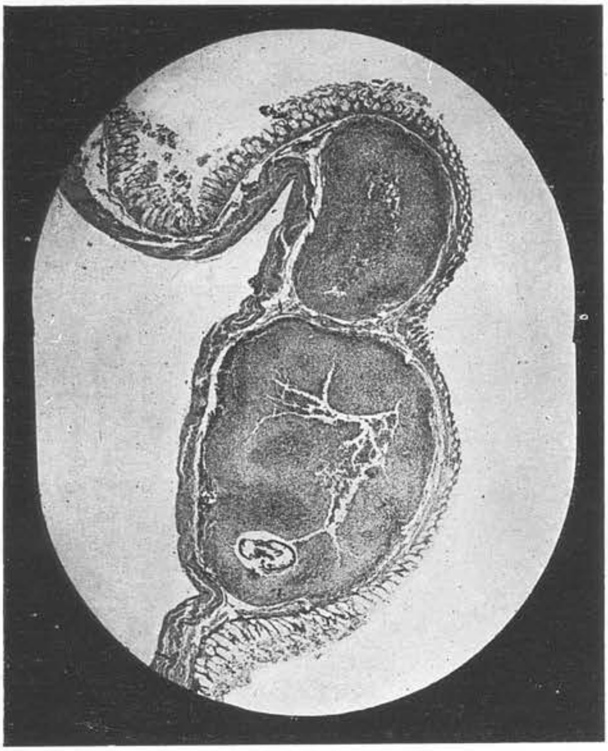


FIG. 12.

Article No. 6.

15th Annual Report of the Director of Veterinary Services, Union of South Africa. October, 1929.

On a Hookworm (*Agriostomum gorgonis*, sp. nov.) from the Blue Wildebeest (*Gorgon taurinus*) in the Transvaal.

By P. L. LE ROUX, B.Sc. (Edin.), M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

INTRODUCTION.

THE type species, the only other member of the genus *Agriostomum* Railliet 1902, was described from the duodenum of a Zebu in Sumatra. Lane (1923) redescribed the species. He examined material from *Bos indicus* at Darjeeling, India. Ware (1925) having obtained specimens from the intestine of *Bos indicus* in the Nilgeri Hills, South India, repeated the description with some additions.

It seems desirable that the type specimens be re-examined to ascertain whether the bifid *dorsal tooth*, as figured by Ware (1928, Figure 1, A), is present. Railliet and Henry (1913) figure no such structure for *Agriostomum vryburgi*. Baylis and Daubney (1926) reoognize Ware's " straight tooth-like organ " to be the dorsal gutter ending in a cone, bifid at the apex.

Agriostomum gorgonis, sp. nov.

This species was collected by Mr. G. A. H. Bedford from the *ileum* of blue wildebeest shot in the Waterberg District, northern Transvaal. These animals harboured also the specimens described as *Haemonchus bedfordi* Le Roux (1929).

The type specimens and the co-types are deposited in the helminthological collection at this Institute.

MORPHOLOGY OF " AGRIOSTOMUM GORGONIS," Sp. Nov.

The specimens preserved in glycerine alcohol are of a dirty white colour, and the body shows fine transverse striations. The portion of the gut immediately behind the oesophagus is very dark owing to the presence of dark granules in the intestinal cells and of dark-coloured ingesta in the lumen of the gut.

From about the oesophago-intestinal junction the males and the females taper towards both extremities. The female ends posteriorly in a fairly long tail acutely pointed. In the male the posterior extremity, owing to the folding in of the lateral lobes of the copulatory bursa, appears markedly attenuated. To the unaided eye the lateral width of the head approximates the maximum breadth of the body. Immediately posterior to the buccal capsule the body narrows to form a distinct neck.

The *oral aperture* faces dorsally and is bounded by the usual six *circum-oral papillae.*

The two *subventral cephalic papillae* are the most conspicuous and figure prominently in the hoodlike expansion of the cuticle extending anteriorly to the ventral margin of the mouth. The *medial* and the *sub-dorsal papillae* are opposite and lateral to the *lateral* and *dorso-lateral buccal teeth* respectively.

The oral aperture, somewhat hexagonal in outline, leads into a spacious buccal cavity with thick cuticularized wall, which has its anterior border armed with fourteen teeth and a cutting plate. These structures are arranged approximately as figured (Figs. 1 and 2).

The two *subventral teeth* are fused medially at the base to form the pair of ventral teeth described and figured for *Agriostomum vryburgi* Railliet (1902). The remaining twelve teeth are grouped into six pairs; two dorso-lateral, two lateral, and two ventro-lateral. Each pair consists of a well-developed external tooth and a shorter, but stout, inner tooth, the latter being partly hidden by the former. One or more of these buccal teeth may occasionally be found with the tip or tips eroded as recorded by Ware (1925) for *A. vryburgi* and by Schwartz (1927) for *Ancylostoma pluridentatum.*

Dorsally there is a short but broad-based cutting plate with semicircular convex cutting edge. The functions of this structure and of the buccal teeth are apparent. That this nematode is an active bloodsucker like the other members of the subfamily cannot be disputed.

The *dorsal oesophageal gland*, with duct penetrating the buccal capsule dorsally, opens into the buccal cavity at the summit of a slight elevation situated behind the dorsal cutting plate (Figure 4).

Anteriorly the medial surface of the mouth capsule carries a projecting structure (Figure 5) suggesting an internal leaf crown.

The cuticularized buccal capsule articulates posteriorly with a circular cuticular ring, surmounting the anterior edge of the oesophagus.

The spacious buccal cavity, with ventral wall much higher than the dorsal one, leads into a well-developed *oesophageal funnel.*

The *oesophagus* is club-shaped, muscular, and anteriorly has its lumen dilated to form the voluminous oesophageal funnel. The oesophago-intestinal union is guarded by the usual valves, well-developed in this species.

The lumen of the intestine is packed with darkish coloured material, probably partly digested blood and epithelial cells. The intestinal cells are packed with a blackish pigment.

The *cervical papillae*, situated about the level of the nerve ganglion, are inconspicuous and may readily escape notice.

The *cervical glands* have the *excretory pore,* not situated in a *cervical cleft* as recorded for the type species. The excretory pore is approximately on a level with the cervical papillae.

Male Characters.

The *genital bursa* in preserved specimens has the lateral lobes folded in. The arrangement of the rays agrees well with that described for *A. vryburgi.* In the majority of individuals the *dorsal* and the *externo-dorsal rays* arise from a stout and comparatively long common trunk. Each *dorsal ray* terminates in two branches, a slender inner branch and a stout lateral branch. The latter is occasionally furnished with a medial accessory offshoot. The *postero-lateral*, the *medio-lateral*, and the *externo-lateral* have a common trunk. The first to branch off is the *externo-lateral*. The common trunk to the *postero-lateral* and the *medio-lateral* is short and the rays lying close together are stout. The *ventral rays*, closely applied, terminate near the edge of the bursa. Variations met with are figured. The *prebursal papillae* are slender and do not project beyond the cuticle in the specimens examined.

The *genital cone* is of the typical ancylostome type, and the spicules are provided with transversely striated alae (Fig. 13).

The *accessory piece*, which in *A. vryburgi* is recorded by Ware (1925) as clavicular in a lateral view and heart-shaped in a dorsal view, is part of a rather ill-defined *telamon*. In whole specimens cleared in lacto-phenol the exact limits of this structure could not be ascertained with certainty. The *telamon* with the spicules attached was dissected out, but even then its outlines were obscured by the muscles adhering to it. When viewed dorsally its anterior portion carries a structure heart-shaped in outline (Fig. 12) and measuring approximately 70 μ × 48 μ. This structure is undoubtedly analogous to the *accessory piece* figured for the type of the genus. According to Ware's drawing (Fig. 1 B) it measures 114 μ × 85 μ. Below this heart-shaped structure referred to above is another similarly shaped part, measuring 42 μ × 32μ. This is apparently a portion of the first mentioned and is situated between the two spicules. The whole structure separates the spicules and secures them in position and forces them to assume a certain direction as they emerge beyond the *telamon*. The alae with their free borders medially directed (Fig. 12) and overlapping the dorsal surface of the first-mentioned heart-shaped structure overlap and envelop each other, and so doing secures the free extremities of the spicules firmly together. Laterally the main body of the *telamon* carries two posteriorly directed wings which secure the spicules laterally. A short distance posterior to their termination the wall of the spicular canal appears again to be slightly chitinized.

Female Characters.

The female is larger than the male, with the posterior extremity ending in a fine tail.

The *genitalia* are of the *oesophagostomum* type. The *vagina* is short and the *vulva*, semilunar in shape, opens on a well-marked ventral prominence (Figure 3).

The *caudal papillae* are readily seen when the worm is rotated. From these the body rapidly narrows, to end in a long thin caudal appendage (Figure 3).

Identity of the Species.

That this parasite is a species distinct from *A. vryburgi* Railliet (1902), is proved by (*a*) the shape and the dimensions of the buccal capsule, (*b*) the size of the oesophageal funnel, (*c*) the number of buccal teeth, and (*d*) the absence of a *cervical groove*.

Lane (1923) points out that *A. vryburgi* forms an interesting link between the Ancylostomidae and the Oesophagostomidae. He proposes for it the subfamily *Agriostominae*, which is included in the family Oesophagostomidae. This suggestion for its inclusion in the family Oesophagostomidae cannot be supported, and it should be retained in the *Ancylostominae* as suggested by Ihle (1922) and by Baylis and Daubney (1926).

TABLE I.

The Measurements (in millimetres) of Males and Females of Agriostomum gorgonis, *sp. nov.*

	Males.	Females.
Length of worm..............................	9–10	11–13
Lateral width of head........................	0·286–0·340	0·320–0·360
Maximum width of body......................	0·312–0·360	0·340–0·370
Width of body in front of copulatory bursa...	0·231–0·280	—
Length of oesophagus..........................	1·400–1·500	1·440–1·500
Maximum diameter of oesophagus anteriorly...	0·234	0·243
Maximum diameter of oesophagus posteriorly..	0·240–0·280	0·250–0·280
Minimum diameter of oesophagus.............	0·140–0·160	0·140–0·180
Lateral width oral aperture..................	0·200–0·220	0·230–0·240
Dorso-ventral diameter of buccal cavity.......	0·156–0·172	0·154–0·176
Lateral diameter of buccal cavity.............	0·187–0·190	0·180–0·200
Height of dorsal wall of buccal cavity........	0·020–0·025	0·020–0·025
Height of ventral wall of buccal cavity.......	0·240–0·260	0·260–0·280
Lateral width of oesophageal funnel...........	0·180–0·210	0·200–0·230
Height of dorsal wall of oesophageal funnel...	0·125–0·156	0·130–0·165
Height of ventral wall of oesophageal funnel..	0·186	0·189
Length of spicules...........................	1·00 –1·20	—
Anterior extremity to excretory pore..........	0·700–0·840	0·780–0·844
Anterior extremity to cervical papillae........	0·800–0·900	0·900–0·950
Vulva to anus...............................	—	0·240–0·300
Anus to posterior extremity..................	—	0·240.0·310

REFERENCES.

BAYLIS, H. A., AND DAUBNEY, R. (1926). "A Synopsis of the Families and Genera of Nematoda," pp. 167-168. (R. Clay & Sons, Ltd., Bungay, Suffolk.)

LANE, C. (1923). "Some Strongylata," *Parasit.*, Vol. 15, p. 348.

LE ROUX, P. L. (1929). "A Preliminary Note on three New Species of *Haemonchus* Cobb, 1898, from Antelopes in South Africa. (See this Report, pp. 451-463.)

RAILLIET, A. (1902). "Sur quelques Sclérostomiens parasites des ruminants et des porcins," *C.R. Soc. Biol.*, Vol. 54, p. 107.

RAILLIET, A., AND HENRY, A. (1913). "Sur les Oesophagostomiens des Ruminants," *Bull. Soc. Path. Exot.*, Vol. 6, pp. 506-511.

SCHWARTZ, B. (1927). "Description of *Anclyostoma pluridentatum*, a Hookworm of Carnivores, and a Review of the Genus *Ancylostoma*," *Proc. U.S. Nat. Mus.*, Vol. 72, Art. 1, pp. 1-9.

WARE, F. (1925). "Two Uncommon Nematode Parasites of Cattle," *Jl. Comp. Path. and Therap.*, Vol. 38, No. 2, pp. 83-85.

YORKE, W., AND MAPLESTONE, P. A. (1926). "The Nematode Parasites of Vertebrates," pp. 91 and 95. (J. & A. Churchill, London.)

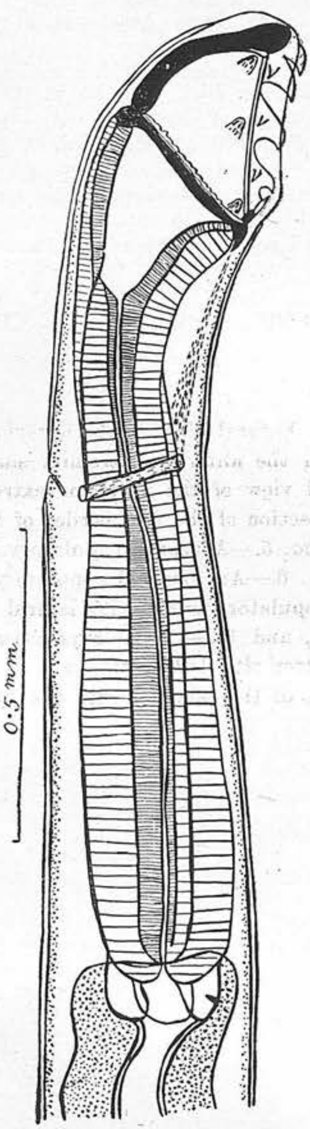


Fig 1.

ADDENDA.

EXPLANATION OF FIGURES.

(PAGES 486–491.)

ARTICLE 29.

Agriostomum gorgonis, sp. nov.

FIG. 1.—Lateral view of the anterior extremity.

FIG. 2.—Dorsal view of the anterior extremity showing the buccal teeth, etc.

FIG. 3.—Lateral view of the posterior extremity of the female.

FIG. 4.—Longitudinal section of the free border of the buccal capsule ventrally.

FIG. 5.—A typical copulatory bursa.

FIG. 6.—An atypical copulatory bursa.

FIG. 7.—Copulatory bursa with lateral lobes folded in.

FIGS. 8, 9, and 10.—Dorsal rays showing variations.

FIG. 11.—Dorsal gutter situated at the base of the dorsal cutting plate.

FIG. 12.—Dorsal view of the telamon with the spicules passing through it.

FIG. 13.—Tip of one of the spicules.

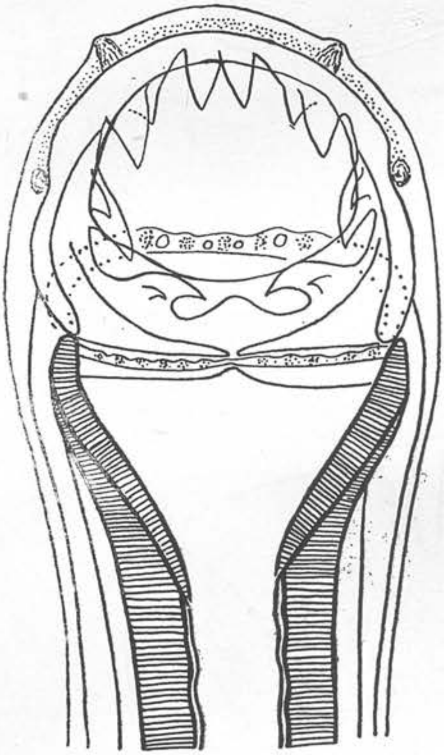


Fig 2.

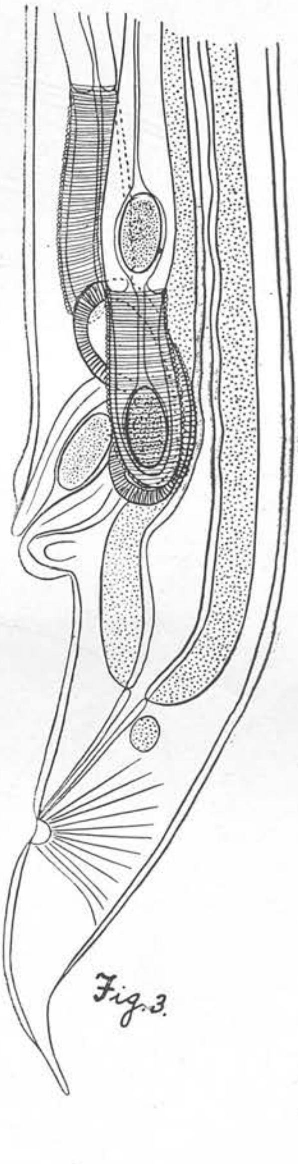


Fig. 3.

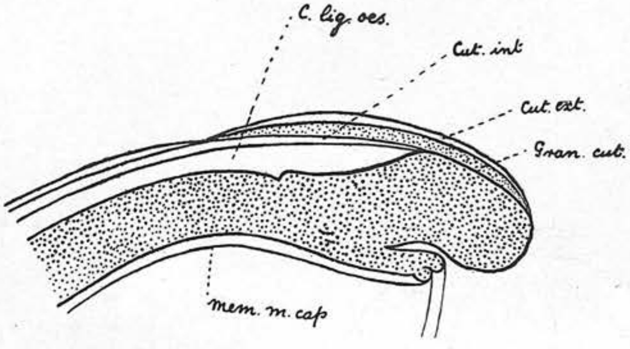


Fig 4.

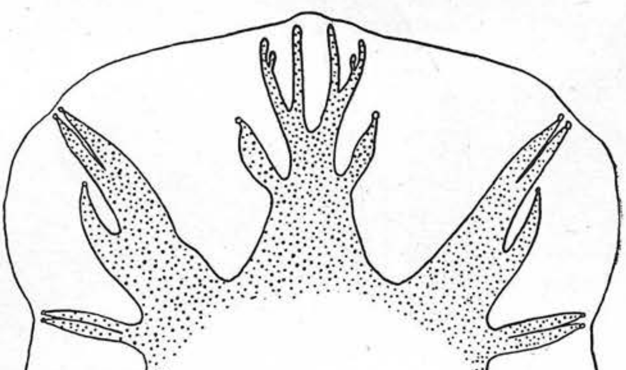


Fig 5.

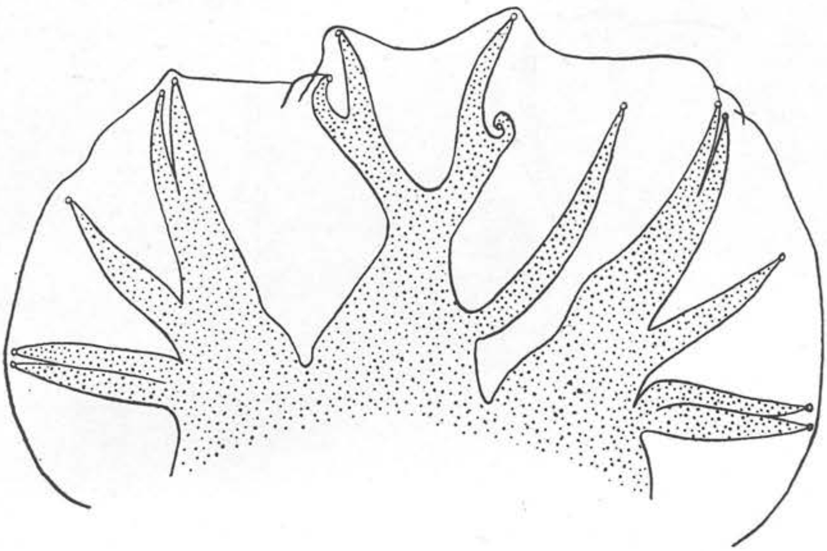


Fig 6.

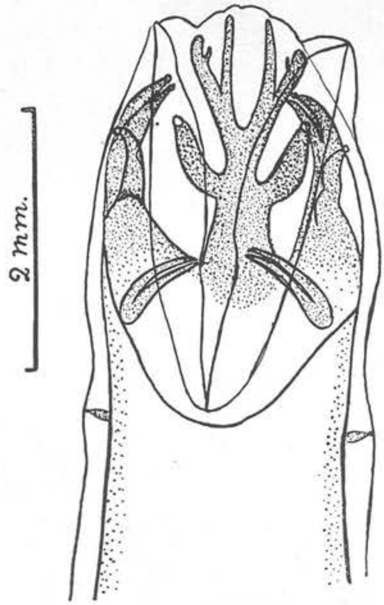


Fig 7.

Fig 8.

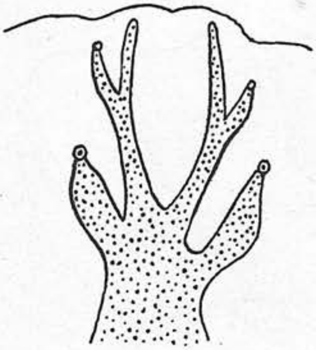
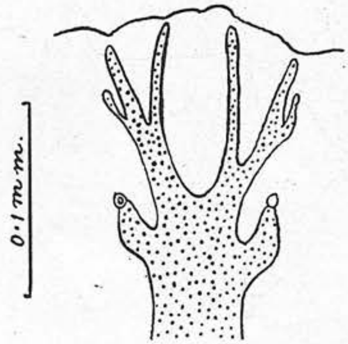


Fig 9.



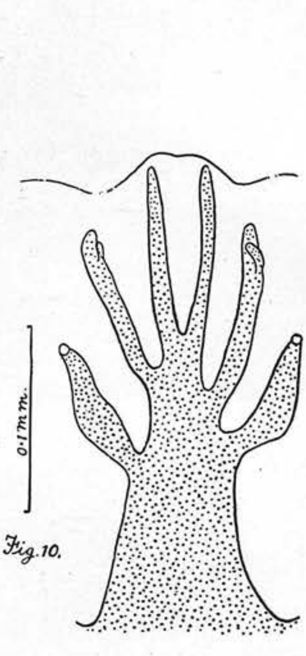


Fig. 10.

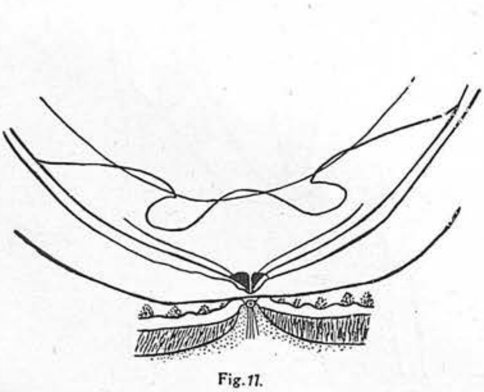


Fig. 11.

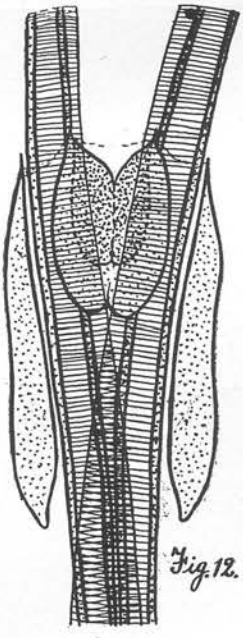


Fig. 12.

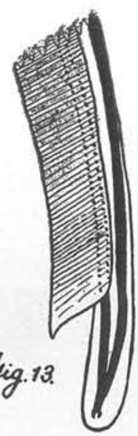


Fig. 13.

Article No. 7.

16th Report of the Director of Veterinary Services and Animal Industry, Union of South Africa, August, 1930.

A Spirurid (*Streptopharagus geosciuri*, sp. nov.) from the Stomach of the Cape Ground Squirrel (*Geosciurus capensis*).

By P. L. LE ROUX, B.Sc., M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

IN July, 1929, the writer collected several nematodes from the stomach of a male Cape ground squirrel. A microscopic examination of these parasites revealed the presence of four specimens (two males and two females) of *Physaloptera capensis* Ortlepp, 1922 and twenty-nine (18 males and 11 females) specimens of a species of *Streptopharagus* Blanc, 1912. Most of the latter are sexually immature. The members of the genus *Physaloptera* were more firmly attached to the gastric mucosa than those of the genus *Streptopharagus*. The members of this genus were found with their anterior extremities buried in the mucosa. The cuticle in the cervical region seems specially modified to this purpose.

Streptopharagus geosciuri, sp. nov.

The males measured vary in length from 12.5 mm. to 16.7 mm. with a maximum diameter of 215μ to 250μ. The corresponding measurements in the females were 24 mm. to 33 mm. and 246μ to 415μ (average for apparently matured specimens 385μ).

The cuticle is transversely striated and is in the region of the oesophagus furnished with low intersected longitudinal ridges formed by a thickened portion of the cuticle between the transverse striations. These thickenings appear like rods. The mouth is bounded by two lateral trilobed lips. The lateral diameter of the cephalic extremity varies from 31μ in the male to 33μ in the female. The buccal cavity continues posteriorly into a tubular pharynx marked with irregular transverse striations. The length of the structure varies with the degree of contraction of the body. The half turn of a spiral displayed about the middle of the pharynx in the known members of this genus is undoubtedly due to contraction of the cephalic extremity. The cuticular cephalic inflation recorded for some members of the genus should probably likewise be attributed to the same agency.

In live specimens of *S. geosciuri* the appearance and the disappearance of the half spiral are readily followed. In only a few cases of the preserved specimens is this half turn of a spiral present and in no single specimen is the cervical cuticle inflated. The pharynx is followed by a long oesophagus measuring 1.7 mm. to 2.1 mm. in the males and 2.1 mm. to 2.6 mm. in the females, and with a maximum diameter of 96μ to 115μ and 112μ to 141μ in the males and females respectively. At the base of the pharynx the width is 35μ to 45μ in the male and 45μ to 58μ in the female. The cervical papillae are asymmetrically arranged. The left papilla is the more anteriorly placed. Mönnig (1924) figures *Streptopharagus armatus* with the right papilla nearer the anterior end. This is undoubtedly not the case. In *S. geosciuri* the left and the right papillae are situated at intervals of 160μ to 170μ (male), 160μ to 245μ (female) and 320μ to 432μ (male), 352μ to 432μ (female) respectively from the anterior extremity. The nerve ring is situated slightly in front of the left cervical papilla. The excretory pore is approximately on a level with the right cervical papilla. In males it is 294μ to 320μ and in females 320μ to 432μ posteriorly to the cephalic end. The cephalic extremity bears the usual six papillae. The four submedians are well defined while the two medians are rather rudimentary. The examination of the cephalic extremity of a female of *Streptopharagus pigmentatus* (v. Linstow, 1897), Rail., and Henry, 1918 from *Papiò porcarius*, Cape Province, confirms Ortlepp's findings that there are two large submedian papillae on each lip, instead of the two groups of three as recorded by Mönnig (1924).

Male Characters.

The posterior extremity has well developed caudal alae and is in preserved specimens strongly coiled, rendering a thorough examination of the ventral surface rather difficult. By allowing specimens to die in cold physiological saline this marked coiling was partly eliminated and allowed of a more careful examination. This examination of unpreserved specimens proved that the presence of the clawlike structures recorded for *Streptopharagus baylisi* Ortlepp 1925 (syn. *Streptopharagus armatus* Blanch of Baylis, 1923), was merely the result of the folding of the ventral cuticle while orientating the caudal extremity under a heavy coverslip so as to obtain a good view of its ventral aspect. These claw-like structures on one side of the cloacal aperture would disappear and reappear on the other side when the coverslip was moved in a reverse direction. It was then evident that what really had happened was that when the coverslip was moved to the right the cuticle on the ventral surface to the left of the anus folds on itself and the thus folded on themselves longitudinal ridges produced the claw-like structures. Their presence in preserved specimens must be due either to the contraction of certain muscles or to the pressure applied for flattening out the bursa. They can no longer be regarded as of any specific generic importance. This observation undoubtedly proves the desirability of examining live or unpreserved specimens whenever possible.

The caudal bursa bears four pairs of preanal and one pair of postanal pedunculated papillae, a single large sessile median papilla on the anterior border of the cloacal aperture, a pair of sessile papillae just behind the anus, and five pairs of small papillae, closely grouped together, on the ventral aspect of the tail. The pair of postanal sessile papillae is somewhat hidden by the cuticular bosses and longitudinal striations in that area. Ortlepp (1925) records their presence in *S. armatus* and in *S. baylisi*.

The presence of a single large sessile preanal papilla has not hitherto been recorded for any of the other members of the genus. Among the *camera lucida* drawings made of helminths during my stay at the London School of Tropical Medicine in 1924, there is one (Fig. 4) of the caudal extremity of a male *Streptopharagus armatus* from *Macacus nemestrinus*. In this drawing there figure a pair of sessile papillae on the posterior lip of the cloacal opening and a single median sessile papilla on the anterior lip of the same aperture. Ortlepp (1925) does not figure this median preanal papilla. Its presence proves the close affinities existing between the genera *Spirocerca* and *Streptopharagus*. Baylis and Daubney (1926) include both these genera in the subfamily Arduenninae Railliet and Henry, 1912, while Yorke and Maplestone (1926) retain them in separate subfamilies. Their retention in separate subfamilies does not seem natural.

The spicules are unequal, the left being 2.23 mm. to 2.62 mm. and the right 416μ to 448μ long. The gubernaculum has a length of 54μ to 64μ.

Female Characters.

The vulva is a rather small circular aperture situated at a distance of 7.5 mm. to 10 mm. from the anterior extremity. The genitalia is of the type as figured by Seurat (1914) for *Spirocerca sanguinolenta* (Rud.). The vagina continues posteriorly to divide into two uteri, one of which turns anteriorly. The eggs in the vagina contain embryoes and measure 35.2μ by 17.6μ. The anus is situated 231μ to 269μ in front of the blunt posterior extremity which carries a pair of caudal papillae.

Remarks.

This species would appear to be closely related to *Streptophargus numidicus* Seurat, 1917, from *Vulpes cerdo*. Ortlepp (1925) records having collected two partly decomposed specimens of *S. numidicus* from *Gerbillus pygarus* and he gives the length of the left and right spicules as 2.2 mm. and 480μ respectively. This compares well with those of the species described here. Seurat's species is inadequately described, and it is therefore impossible to ascertain with any degree of certainity whether it is identical with the species from *Geosciurus capensis*.

REFERENCES.

BAYLIS, H. A., AND DAUBNEY, R. (1926). A Snyopsis of the Families and Genera of Nematoda. Richard Clay & Sons, Ltd., Bungay, Suffolk, England.

BLANC, G. (1912). "Un Nématode nouveau (*Streptopharagus Armatus*, n. gen. n. sp.) Parasite du Macaque (*Macacus cynomolgus*)." *Comp. Rend. Soc. Biol.*, Vol. 72, pp. 456-457. Paris.

MÖNNIG, H. O. (1924). "South African Parasitic Nematodes." *9th and 10th Rept. Dir. Vet. Educ. and Res.*, pp. 446-448. Pretoria.

ORTLEPP, R. J. (1925). "A Review of the Members of the Genus *Streptopharagus* Blanc, 1912." *Jl. Helm.*, Vol. 3, No. 5, Dec., pp. 209-216. London.

SEURAT, L. G. (1917). "Sur les Spiroptères de Carnivores du Nord-Africain." *Bull. Soc. Hist. de L'Africa du Nord*, Vol. 8, p. 23. Algiers.

SEURAT, L. G. (1918). "Contribution à l'étude de la Faune Parasitaire de la Tunisie." *Arch l'Inst. Past. Tunis*, Vol. 10, pp. 265-267. Tunis.

SEURAT, L. G. (1920). Histoire Naturelle des Nematodes de la Berberie. Algiers.

YORKE, W., AND MAPLESTONE, P. A. (1926). The Nematode Parasites of Vertebrates. J. & A. Churchill, London.

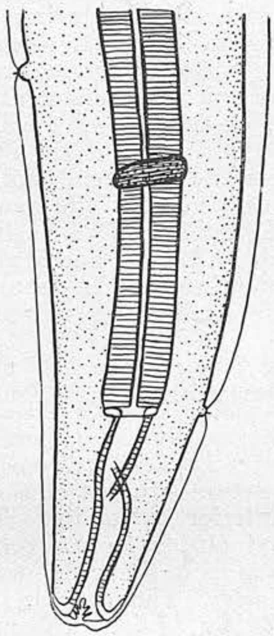


FIG. 1.
Dorsal view, anterior extremity of *S. geosciuri.*

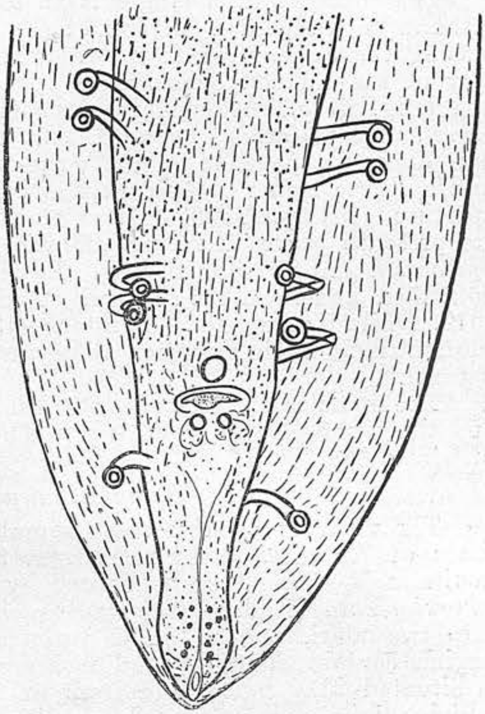


FIG. 2.
Ventral surface, posterior extremity of a male—*S. geosciuri.*

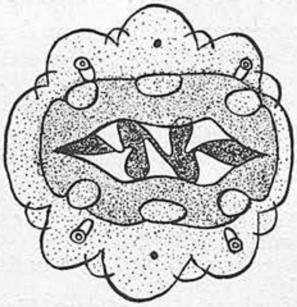


FIG. 3.
Anterior view of the cranial end in *Streptopharagus pigmentatus.*

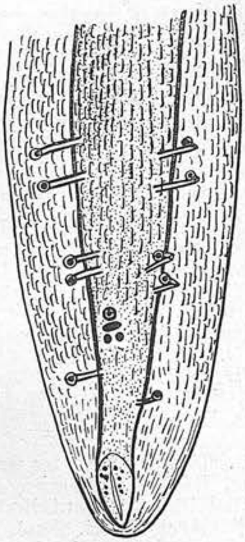


FIG. 4.
Caudal extremity of *Streptopharagus armatus* from *Macacus nemestrinus.*

Article No.8

16th Report of the Director of Veterinary Services and Animal Industry, Union of South Africa, August, 1930.

The Generic Position of *Oxyuris polyoon* von Linstow, 1909, in the Sub-family *Oxyurinae*, Hall, 1916.

By P. L. LE ROUX, B.Sc., M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

IN July, 1929, the writer collected and preserved in glycerine alcohol oxyurids from the caecum and colon of a Cape ground squirrel (*Geosciurus capensis*, syn. *Xerus setosus*) shot on a farm in the district of Bloemhof, Transvaal. The examination of specimens cleared in lacto-phenol proved them to be specimens of *Oxyuris polyoon* von Linstow, 1909. This species was originally recovered from the same host at Rehoboth, in the then German South West Africa.

The original description of this worm is so meagre that Hall (1916) expressed the view that it should probably be transferred to the genus *Dermatoxys* Schneider, 1866. Hall was most likely influenced by Seurat's (1915) remarks that von Linstow's species was very closely related to the species *Dermatoxys getula* described by him from the caecum of *Atlantoxerus getula* (syn. *Xerus getulus*) in Morocco. Yorke and Maplestone (1926) list *D. polyoon* (v. Linstow, 1909) as a doubtful species of *Dermatoxys*.

An examination of the specimens collected by the writer proved that von Linstow's species is a member of the genus *Enterobius* Leach, 1853, and is, therefore, re-named *Enterobius polyoon* (v. Linstow, 1909). As synonyms should be cited:—*Oxyuris polyoon* von Linstow, 1909, and *D. polyoon* (von Linstow, 1909), Yorke and Maplestone, 1926.

MORPHOLOGY OF *Enterobius polyoon* (v. LINSTOW, 1909).

Specific diagnosis, Enterobius: Mouth with three prominent lips (one dorsal and two subventral); cuticle inflated anteriorly, and transversely striated; narrow lateral alae arising close behind the nerve ring and extending almost to the posterior extremity in the female; no buccal capsule; oesophagus with a club-shaped anterior portion separated from the oesophageal bulb by a constriction, oesophageal bulb containing a valvular apparatus; excretory pore opening slightly caudal to the posterior limit of the oesophagus, nerve ring just posterior to the cephalic inflation.

Male: Posterior extremity truncated, caudal alae supported anteriorly by a pair of stout pedunculated preanal papillae and posteriorly by a somewhat similar pair arising from a sublateral position close to the caudal extremity of the body, and laterally by a pair of adanal papillae followed by a pair of postanal papillae: another pair of caudal papillae much reduced in size and not supporting the alae, situated more dorso-laterally than the others; spicule single and relatively long, gubernaculum absent.

Female: Vulva in anterior half of the body; ovejector well developed with the uteri leaving in opposite directions; in gravid females the uteri extending anteriorly half-way up the oesophagus and posterior to the anus; oviparous, eggs with a thick smooth shell.

The Male.

Six of the larger males were selected for the various measurements. They varied in length between 3.4 mm. to 3.7 mm. with a maximum thickness of 277μ to 365μ about the junction of the middle and posterior thirds of the body. The oesophagus measures 836μ to 927μ in length. The anterior club-shaped portion varies between 713μ to 783μ in the different specimens. This portion has a minimum diameter of 38μ to 44μ while the maximum ranges from 70μ to 77μ. The oesophageal bulb measures 128μ to 144μ in length and its width varies between 118μ and 144μ. The lateral diameter of this portion often exceeds its antero-posterior dimension.

The width of the cephalic extremity immediately anterior to the inflation is approximately 51μ while that of the cephalic inflation ranges from 96μ to 115μ. The antero-posterior dimensions of this inflation are 40μ to 112μ on the dorsal and ventral aspects by only 80μ to 95μ on the lateral aspects. In some specimens the dorsal measurement exceeds the ventral but this is reversed in others. Cameron (1929) observes that in *E. vermicularis* the swelling is longer laterally than on the dorsal or ventral aspect.

The excretory pore is situated about 48μ to 64μ behind the posterior limit of the oseophagus while the lateral alae arise at a point situated 243μ to 288μ posterior to the cephalic extremity.

The single testis pass to within 532μ to 380μ of the base of the oesophagus before turning posteriorly. The spicule is heavily chitinised anteriorly and is here furnished with antero-laterally directed lateral appendages. These appendages appear rather fibrous. The spicule, including the appendages, has a length of 262μ to 275μ. The chitinised portion alone measures 214μ to 220μ and has a maximum dorsal-ventral depth of 32μ. In specimens cleared in lacto-phenol the spicule was distorted. It was much swollen about the junction of the posterior and middle third. This distortion was even more marked in a ventral view of the spicule. It would be interesting to know whether the spicules of the other members of this genus are susceptible to similar distortion in lacto-phenol.

A gubernaculum proper is absent but the spicule is evidently guided by a thickening of the dorsal wall of the spicular canal posteriorly. In longitudinal section this thickened portion seems to be composed of material identical with that of the walls of the rectum.

The ventrally curved truncated posterior extremity is furnished with well-developed caudal alae supported by four pairs of pedunculated papillae (one pair preanal, a pair of adanal and two pairs of postanal). The caudal extremity is armed with an additional pair of papillae situated dorsally to the roots of the postanal papillae. This pair of rather slender papillae are by no means conspicuous and is not figured by von Linstow (1909) for *O. polyoon*. That the analogous pair may be readily missed in the type species of the genus is evident from Fig. 122 D. of Yorke and Maplestone (1926). Lane and Low (1923) figure six pairs of caudal papillae for *E. vermicularis*. Sluiter, Swellengrebel and Ihle (1921) defining the characteristics of the genus *Enterobius* mention that the caudal alae are supported anteriorly by one pair of pedunculated preanal papillae and posteriorly by two pairs of ordinary papillae. They also mention two additional pairs of sessile postanal papillae. In their brief description of the male of *E. vermicularis* they state that there are present on the tail six pairs of small papillae of which the anterior and the posterior are the larger. Cameron (1929) records and figures five pairs of caudal papillae for this worm. He mentions that the pair before the last is very slender. This pair corresponds to the additional pair mentioned above for *E. polyoon*.

The Female.

Females and males are present in approximately equal numbers and the former are not very much larger than the latter. The larger specimens were measured. They vary from 5.25 mm. to 7.5 mm. in length and a maximum thickness of 308μ to 465μ was reached just posterior to the vulva which is situated at a distance of 1.58 mm. to 1.76 mm. from the cephalic extremity. The length of the oesophagus is 1.02 mm. to 1.1 mm. The anterior portion is 851μ to 942μ while the bulbular portion measures 152μ to 160μ. The minimum and the maximum diameters of the prebulbular portion are 48μ and 86μ to 96μ respectively, while the bulbular portion has a width of 165μ to 184μ.

The anterior cuticular inflation is as prominent as in the males, while the lateral alae are readily visible and arise at a point siuated between 246μ and 330μ from the anterior end. The anus is situated between 1.12 mm. and 1.33 mm. in front of the posterior extremity.

The ovejector runs caudally for approximately 1.25 mm. before dividing into the two uteri, one passing anteriorly and the other posteriorly. The uteri are voluminous and closely packed with thick-shelled eggs measuring 64μ by 25μ. The eggs have one side somewhat flattened, causing them to appear asymmetrical in outline when orientated into a certain position. Some of the more matured eggs contain partly developed embryos. The eggs would therefore appear to be deposited in an advanced stage of segmentation. No eggs were recovered from the faecal matter in the caecum or any other part of the alimentary tract.

REFERENCES.

BAYLIS, H. A. (1928). "Some further Parasitic Worms from Sarawak." *Ann. Mag. Nat. Hist.* (10th Series), Vol. 1, pp. 606-608. London.

CAMERON, T. W. M., 1929. "The species of *Enterobius* Leach in Primates." *Jl. Helm.*, Vol. 7, No. 3, July, pp. 161-182, London.

HALL, M. C. (1926). "Nematode Parasites of Mammals of the Orders *Rodentia*, *Lagomorpha*, and *Hyracoidea*." *Proc. U.S. Nat. Mus., Washington*, Vol. 50, 258 pp.

LANE, C., AND LOW, G. C. (1923). "Intestinal Infestations other than Ankylostomiasis." *The practice of Medicine in the Tropics*, Vol. 3, pp. 1877-1902. H. Frowde and Hodder & Stoughton, London.

SLUITER, C. PH., SWELLENGREBEL, N. H., AND IHLE, J. E. (1921). *De Dierlyke parasieten van den Mensch en van onze Huisdieren.* Scheltema & Holkema, Amsterdam.

YORKE, W., AND MAPLESTONE, P. A. (1926). *The nematode Parasites of Vertebrates.* J. & A. Churchill, London.

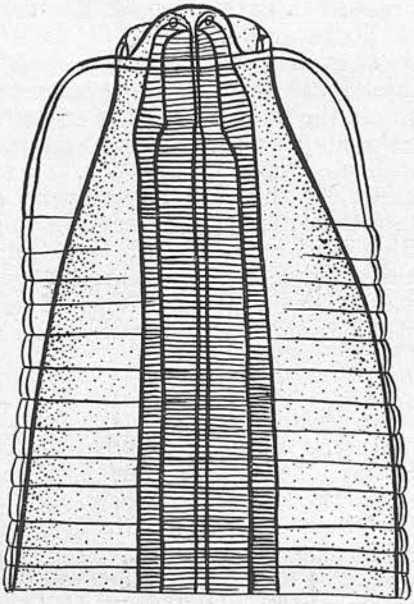


Fig. 1.

Dorsal view of the anterior extremity.

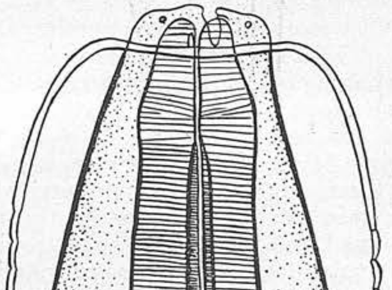


Fig. 2.

Lateral view of the anterior extremity.

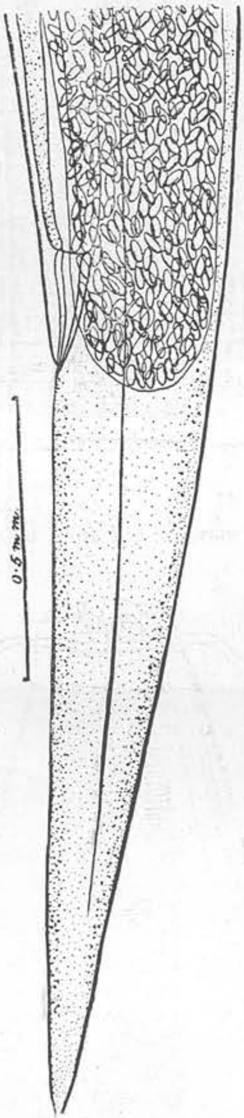


Fig. 3.

Lateral view of the posterior extremity of the female.

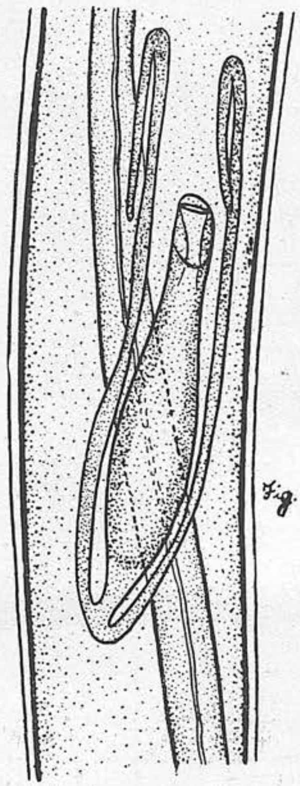


Fig. 4.

Female genitalia in an immature female.

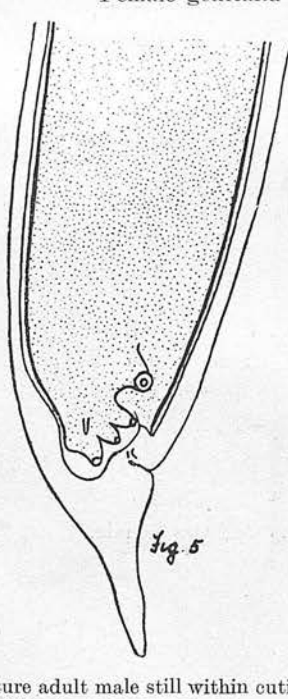


Fig. 5

Immature adult male still within cuticle of the former larval stage.

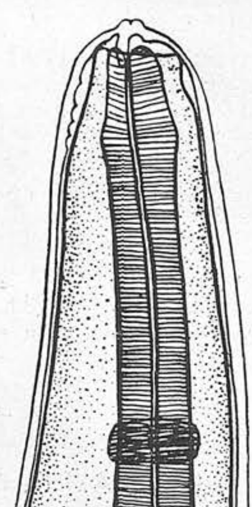


Fig. 6

Anterior extremity of immature adult still within cuticle of the former larval stage.

Article No.9.

16th Report of the Director of Veterinary Services and Animal Industry, Union of South Africa, August, 1930.

An Acuaria (*Acuaria martinagliai* sp. nov.) from a South African Weaver (*Hyphantornis* sp.).

By P. L. LE ROUX, B.Sc. (Edin.), M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

INTRODUCTION.

IN December, 1929, Dr. G. Martinaglia visited Johannesburg in connection with an outbreak of Fowl Typhoid amongst a flock of Leghorns. To investigate the possible dissemination of this widespread disease by some of the smaller wild birds, he requested the poultryman to trap some of the Weavers and Cape Sparrows that visit the poultry pens regularly. It is from one of these trapped Weavers that Dr. Martinaglia's assistant, Mr. Grobler, collected two female acuarias. On a personal examination of the gizzard I secured a solitary male. The name *Acuaria martinagliai*, sp. nov. is designated for this worm in honour of my Colleague, Dr. Giovanni Martinaglia, who has contributed much towards our knowledge of the maladies affecting the domestic fowl in South Africa.

The weaver was unfortunately not identified with certainty but is probably *Hyphantornis velatus arundinarius* (Burch).

This is apparently the first record of a member of the genus Acuaria (Bremser, 1877), Cram, 1927, from South Africa.

The chief measurements of the three specimens are appended (see Table 1).

MORPHOLOGY.

Macroscopic Characters.

The fine and hair-like body is in freshly collected specimens practically colourless. These characters camouflage the presence of the parasite on the surfaces exposed after the removal of the horny layer lining the lumen of the gizzard. The females were detected as this lining was separated from the muscular wall of the organ. The male was only discovered on scraping the newly detached surface of the inner tunic with a fine dissecting needle.

Microscopic Characters.—After preservation in boiling glycerine alcohol the specimens were perfectly straight. The caudal extremity of the male was not ventrally curved as is usually the case with *Cheilospirura hamulosa*. The latter is a very common parasite of the muscular portion of the gizzard of South African fowls on free range.

The cuticle bears very fine transverse striations. About the junction of the two portions of the oesophagus they are approximately 3.5μ apart.

The anterior extremity is furnished with a roughly pyramidal-shaped head. The oral aperture is bounded laterally on each side by a conical lip 6-8μ high. The exact limits of these lips can only be ascertained with certainty when the head is viewed either dorsally or ventrally. From a comparison of the descriptions of the different species of *Acuaria* it is evident that some authors are undoubtedly crediting some of the members of the genus with larger lips than they can possibly possess. Most of the recorded species would appear rather inadequately described and figured.

The head is furnished with the usual six head papillae common to most, if not all nematodes. Each lateral aspect of the " pyramid " bears slight pedunculated subdorsal and subventral head papillae towards the angles at the base. In addition to these each also has a rather poorly developed and inconspicuous median head papilla situated about halfway between the apex and the base.

The oral aperture leads into a tubular pharynx with fairly thick wall which appears to be transversely striated. The pharynx is followed by an oesophagus differentiated into an anterior fairly transparent muscular portion and a stouter and more granular posterior portion (the glandular oesophagus).

The inlet to the intestine is guarded by the usual oesophageal valves.

A pair of cordons arise from each oral commissure, and diverge as they cross the dorsal and ventral surfaces of the " pyramid " to proceed true caudally on gaining the subdorsal and subventral median lines of the body. The subventral pair stop slightly short of the posterior limit of the corresponding subdorsal pair. The cordons project but very slightly from the cuticular surface and are not recurrent or anastomosing.

The cervical papillae are rather small and difficult to locate. The left is slightly more posteriorly localized than the right.

The nerve ring is prominent and encircles the muscular oesophagus close to its cephalic end.

Male Characters.—The body attains its maximum width just in front of the caudal bursa which has well developed lateral alae. There are twelve pairs of caudal papillae of which five pairs are definitely preanal, one pair practically adanal and the rest postanal. The postanal pairs are pedunculated and conspicuous, while the others are only very slightly pedunculated or not at all. The spicules are well developed with the right slightly longer but thinner than the left. The single testis extends anteriorly to the base of the oesophagus and turns back.

Female Characters.—The vulva, circular in outline, is localized at the summit of a prominent mound. The dorso-ventral diameter at this point is 200 to 228μ which is also the maximum width of the body. The vagina is anteriorly directed and its first part measures approximately 200μ by 40μ. The ovaries are opposed. The cranial one extends anteriorly and about halfway up the length of the glandular portion of the oesophagus while the posterior one reaches close up to the rectum before turning cranially. The posterior extremity terminates in a long but rather thick blunt tail, furnished with well-defined subterminally placed caudal papillae.

The uteri and the vagina are packed with thick (4μ) shelled eggs. A large percentage of these eggs are embryonated.

TABLE I.

The Chief Measurements (in Millimetres) of the three specimens.

	Sex.		
	Male.	Females.	
Length of body	8·3	22·5	26·2
Maximum width of body	0·100	0·200	0·228
Anterior end of body to excretory pore	0·280	0·340	0·390
Anterior end of body to cervical papillae—			
Right	0·200	0·228	0·248
Left	0·210	0·256	0·260
Anterior end of body to nerve ring	0·220	0·250	0·260
Anterior end of body to termination of cordons—			
Subventral	0·180	0·348	0·400
Subdorsal	0·260	0·480	0·500
Measurements of pharynx—			
Length	0·180	0·204	0·200
Width	0·017	0·019	0·020
Measurements of first portion of oesophagus—			
Length	0·576	0·592	0·592
Width	0·028	0·040	0·046
Measurements of second portion of oesophagus—			
Length	1·360	2·400	1·680
Width	0·068	0·080	0·116
Anus to posterior extremity of body	0·204	0·280	0·285
Length of spicules—			
Right	0·146	—	—
Left	0·140	—	—
Vulva to posterior extremity of body	—	19·0	12·0
Eggs *in utero* and *in vagina*—			
Length	—	0·040	0·044
Width	—	0·025	0·027

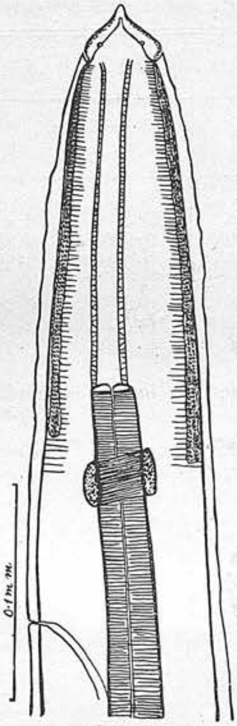


Fig. 1.

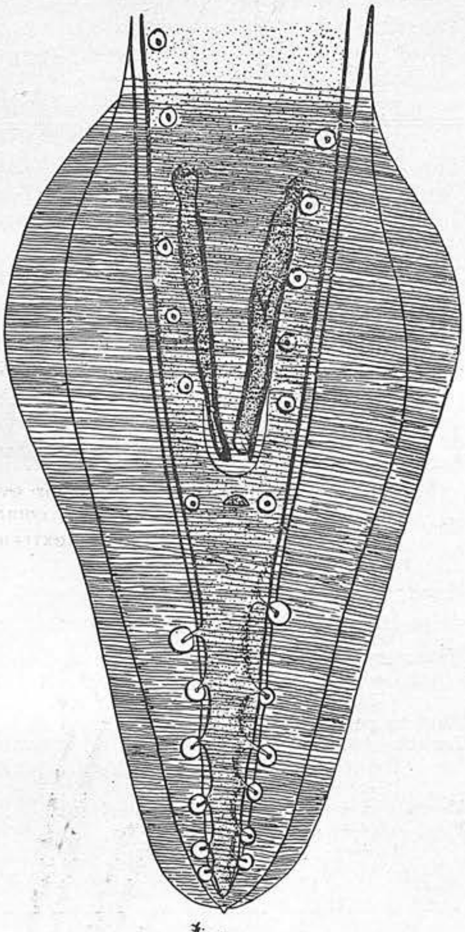


Fig. 2

Fig. 1. Lateral view of the anterior extremity, showing the cordons, etc.
Fig. 2. Ventral view of the caudal extremity in male.

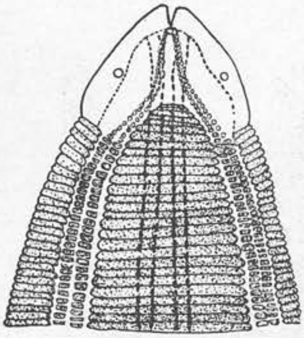


Fig. 3.

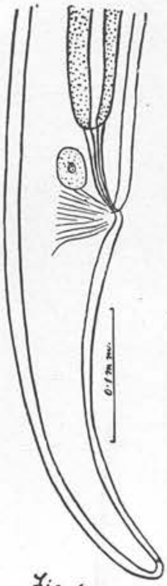


Fig. 4.

Fig. 3. Ventral view of the anterior extremity, showing origin of cordons at oral commissure.

Fig. 4. Caudal extremity of a female.

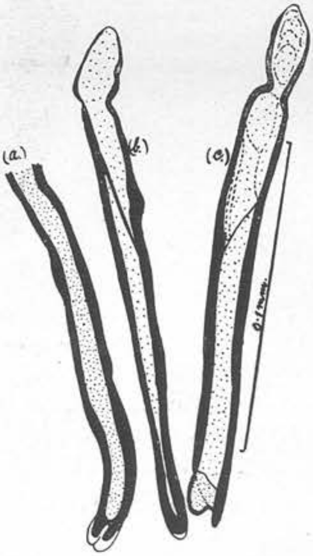


Fig. 5.

Fig. 5 (*a*) Lateral view of right spicule.
Fig. 5 (*b*) Dorsal view of right spicule.
Fig. 5 (*c*) Lateral view of left spicule.

Article No.10.

16th Report of the Director of Veterinary Services and Animal Industry, Union of South Africa, August, 1930.

A New Nematode (*Rictularia aethechini, sp. nov.*), a *Physaloptera* and an *Acanthocephala* from the Hedgehog (*Aethechinus frontalis*).

By P. L. LE ROUX, B.Sc. (Edin,), M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

INTRODUCTION.

In September, 1929, the writer collected four species of helminths from the alimentary tract of a young male hedgehog (*Aethechinus frontalis* syn. *Erinaceus frontalis*) caught close to Hamanskraal Railway Station, Transvaal.

From the stomach were collected a few specimens of a species of *Physaloptera* Rud. These have tentatively been identified as specimens of *Physaloptera dispar*, von Linstow, 1904 (Syn. *Physaloptera incurva*, von Linstow, 1908 recovered from the stomach and intestine of *Erinaceus frontalis* in the Kalahari Desert area.

The small intestine yielded a few tape worms, several Acanthocephala belonging to the genus *Moniliformis* Travassos, 1915 and twelve (four males and eight females) specimens of *Rictularia*, Frölich, 1802. The latter could not be identified with any of the hitherto described members of the genus *Rictularia* and the name *Rictularia aethechini* sp. nov. is proposed for them.

RICTULARIA AETHECHINI sp. nov.

Four males and eight females were collected, examined and measured. The more important measurements are tabulated (see Table I). Some of the specimens were examined alive at the time of their collection.

Macroscopic Appearance and Habits.—The live worms were of a reddish colour and were firmly attached to the intestinal mucosa. On their removal by means of a pair of fine pointed pincettes haemorrhagic spots marked their former sites of attachment. That these parasites suck blood and feed on the cells of the intestinal mucosa are evident. The structure of the buccal cavity is well adapted to those ends. Portions of the intestinal mucosa invariably came away attached to the oral armature, and could not always be removed by shaking the worms vigorously in a tube containing normal physiological saline. On preservation in hot glycerine alcohol the reddish colour of the live specimens was replaced by a dirty white. The females are practically straight while the males appear with the posterior extremity strongly bent ventrally (Figure 3.) The cephalic end is in both sexes more attenuated than the posterior and the anterior third of the body is slightly ventrally retracted.

Microscopic Characters common to both sexes.—Except for the characters of the buccal capsule, the cephalic and cervical papillae, the oesophagus and the excretory pore, there is little of specific value that is common to both sexes. The cuticle, for practically the entire length of the parasite, is furnished with a row of cuticular appendages along the subventral line on each side. Anteriorly these cuticular appendages, also known as "combs," overlap each other. Posteriorly they are represented as well defined cuticular spines, and are spaced fairly wide apart. The transition from "combs" into "spines" is somewhat gradual. Baylis (1928) observes that too much stress has been laid in many of the descriptions of species of *Rictularia,* upon the distinction between "combs" and "spines." These structures are merely degrees of modification of the same structure. In *R. aethechini* sp. nov. the "combs" consist of a dorso-ventrally flattened free ridge. This ridge increases in height towards its posterior termination where it has a well-marked posterior border forming an angle with the long free lateral border. It is this posterior external angle which becomes more and more acute until we have a definite spine. (Figures 7, 8 and 9.)

Along each side of the attached border of the ridge the cuticle is most characteristically thickened and striated.

Most of the species of *Rictularia* are rather inadequately described as regards the build of the buccal cavity and the characters of the cuticular appendages which are undoubtedly adaptations for progression and anchorage.

The subterminally placed oral aperture faces dorsally and is pentagonal in outline (Figure 2). The buccal capsule is a somewhat complicated structure. Its walls are heavily chinitised and thick (maximum thickness of dorsal, ventral and lateral walls varies from 12μ to 16μ). Its anterior free margin is armed with teeth varying in shape and magnitude. The single mid-ventral tooth (v.b.t. Figure 7) is a continuation of the ventral wall and is long and stout. This tooth has its buccal surface concave both in length and width and it should perhaps be more correctly termed a ventral cutting plate. Mid-laterally the oral aperture on both sides is guarded by a fairly stout lateral buccal tooth (l.b.t. Figure 1). It is triangular in outline and points anteriorly and dorsally.

Between the bases of the above-mentioned teeth the margin of the buccal cavity is armed with smaller teeth which would appear to be homologous with the "row of denticles" described by Hall (1914) for *R. splendida* and by others for different species of *Rictularia.*

In addition to the above-mentioned structures the buccal capsule is characterized by a well-developed *dorsal gutter* arising from the floor and partly from the dorsal wall of the buccal capsule with a length of 50μ to 60μ. In dorsal view it is triangular in outline.

In lateral aspect there appear on the floor of the oesophagus three well-defined projections which will be referred to as oesophageal teeth. They correspond in position to the three sectors of the oesophagus. In lateral view the subventral teeth appear roughly triangular in outline (subv. o.t., Figure 7), while the *dorsal oesophageal tooth* (Figure 7), rather stout and with rounded tip, is directed anteriorly and ventrally. In a dorsal view the *subventral oesophageal teeth* show prominently.

The cephalic papillae are well-developed and rather characteristic. Each papilla ends in a crescent-shaped structure which appears slightly chinitised. Owing to the distortion of the cephalic extremity the arrangement of the papillae in this genus is somewhat different from that usually met with in nematodes, with the oral opening facing true anteriorly. Their positions except for the behaviour of the subventral pair resemble that of the *Ancylostomidae.* The *subventral cephalic papillae* figure prominently in the anterior half of the cephalic extremity. In dorsal or ventral aspect they appear with a thick common stem but with their extremities free and each ending separately in a crescent-shaped apparently chinitised claw-like structure.

The lateral pair of cephalic papillae is on the anterior level of the buccal cavity while the subdorsal pair is just posterior to the edge of the oral aperture. Hall (1914) observes that head papillae, while doubtless present, are not evident in the male of *R. splendida.* In the female he found them to be ill-developed. Schulz (Figures 17 and 18, 1927) figures for *Rictularia amurensis* Schulz, 1927 prominent cephalic papillae ending in crescent-shaped structures. Baylis (1928*a*) figures for *Rictularia myöbergi* double lateral papillae and neither these nor any of the others have crescent-shaped terminations.

Anteriorly the cervical cuticle is inflated dorsally and ventrally. This inflation is more pronounced dorsally (Figure 1.)

The *oesophagus* is long and consists of an anterior transparent muscular portion followed by a longer and more granular posterior portion.

The *nerve ring* encircles the anterior portion of the oesophagus about its middle.

The cervical papillae are rather short and delicate structures and can be readily overlooked. They are localized about the level of the sixth to seventh cuticular appendage and slightly posterior to the excretory pore which is most difficult to locate owing to it being obscured by the sixth or the seventh cuticular appendage.

The cuticle bears fine transverse striations at intervals of 9μ to 10μ.

Male Characters.—The cuticular appendages extend further caudad than in the females. Each subventral row consists of approximately forty-one " combs " and nine " spines." The so-called transition from " combs " to " spines " is more sudden than in the opposite sex. The first appendage is close to the cephalic extremity. The last pair is usually rudimentary and physiologically defunct.

The single testis is well developed and extends almost to the posterior end of the oesophagus before turning back. There are two rather unequal spicules and rather rudimentary and ventrally situated accessory piece.

The strongly ventrally bent caudal extremity is without alae. The ventral surface is ornamented with cuticular peri-cloacal markings. There are three pairs of pre-anal and five pairs of post-anal sessile papillae. The cloaca opens on the summit of a slight mound. Anterior to the most anterior pair of pre-anal papillae there is in the midventral line a wart-like structure, 100μ in height with an antero-posterior diameter of 160μ. This structure is situated 160μ in front of the anus. The median ventral " combs " of Baylis (1928*b*) or the ventral fans of Hall (1914) were not observed on the ventral surface on any one of the four males of *R. aethechini*.

Female Characters.—The transition from " combs " to " spines " is gradual. There are relatively forty-six combs and twenty-nine spines to each row. The free extremity of the most posteriorly placed spines projects hardly beyond the cuticle. In most cases the last pair is rather rudimentary and merely represented by a thickening of the cuticle. In a young specimen the last pair of spines is anteriorly directed.

The vulva is just posterior to the base of the oesophagus and opens ventrally as a transverse slit opposite the forty-second cuticular appendage. The short and relatively thick vagina continues posteriorly and divides into two *uteri* lying parallel to each other. The *uteri* are packed with eggs. A large percentage of these are embryonated.

The rather short blunt tail ends in a small conical knob. The usual *caudal papillae* are close to the posterior extremity.

Affinities.—About fifteen species of *Rictularia* have hitherto been described from rodents, insectivora and carnivora from various countries. Most of these species are rather inadequately described and figured. *Rictularia aethechini* does not seem to be closely related to any of them.

The sub-family *Rictulariidae* was founded by Hall (1913) because *Rictularia* Frölich, 1802, could not be referred to any of the then established sub-families of the family *Metastrongylidae* Railliet and Henry, 1910. The allocation of genus *Rictularia* to the *Metastrongylidae* cannot be accepted.

Hall (1913) based his conclusion on the structure of the buccal capsule, the oesophagus, the spicules and the female reproductive glands. He, however, observes that it does not possess the normal strongyle bursa and that the cuticular ornamentation and the fact that it is ovoviviparous are not typical conditions in the *Strongylidae*.

Railliet (1916) created the family *Rictulariidae* and included it in the super-family *Spiruroidea* Railliet and Henry, 1915. Yorke and Maplestone (1926) accept Railliet's classification. Baylis and Daubney (1926) express the belief that the genus under consideration should be included in the sub-family *Thelaziinae* of the *Spiruroidae* Oerley (1885). These authors disregard Railliet and Henry's (1915) classification and assign to the super-family *Filarioidea*, Weinland (1858) the families which are grouped in the super-family *Spiruroidea* by Yorke and Maplestone (1926.)

Baylis (1928*a*) still assigns the genus *Rictularia* to the family *Spiruroidae*. The retention of the super-family *Spiruroidae* with the family *Rictularidae* as one of its sub-divisions would undoubtedly simplify rather than complicate the classification of nematodes.

TABLE I.

Measurements (in millimetres) of Males and Females of *Rictularia aethechini* sp. nov.

	Male.	Female.
Length	5–8·5	15–21
Maximum diameter of body	0·400–0·580	0·536–0·608
Lateral diameter of head	0·132	0·128–0·140
Distance from anterior extremity to 1st comb	0·084–0·096	0·100–0·110
Distance from anterior extremity to nerve ring	0·320–0·440	0·400–0·460
Distance from anterior extremity to excretory pore	0·400–0·480	0·715–0·740
Distance from anterior extremity to base of oesophagus	0·112–0·130	0·132–0·140
Distance from anterior extremity to vulva	—	5·10 –7·500
Length of muscular portion of oesophagus	0·355–0·656	0·624–0·950
Maximum width of muscular portion of oesophagus	—	—
Length of glandular portion of oesophagus	1·920–2·400	3·230–4·200
Maximum width of glandular portion of oesophagus	—	—
Distance from anus to posterior extremity	0·150–0·225	0·144–0·200
Measurements of the eggs in uteri—		
Length	—	0·050–0·060
Width	—	0·032–0·044
Length of spicules—		
Right	0·118–0·132	—
Left	0·190–0·225	—
Length of gubernaculum	0·028–0·034	—

PHYSALOPTERA sp.

The species of *Physaloptera* which have hitherto been recorded from different species of hedge-hogs are:—

1. *Physaloptera clausa* Rud., 1819 from *Erinaceus europaeus*. Seurat's (1917) redescription of the parasite is based on specimens collected from *E. algirus* and *E. deserti* of Northern Africa. This author mentions *Physaloptera dispar* v. Linstow (1904), as a synonym of the type species. Ortlepp (1922) having examined the specimens of *P. clausa*, preserved in the helminthological collection of the Vienna Museum and specimens in the collection of Prof. R. T. Leiper, points out that his observations differ in many respects from those of Seurat. Ortlepp further observes that Schneider (1866) also was probably not dealing with *P. clausa* but a species identical with or closely related to Seurat's specimens.

2. *Physaloptera dispar* v. Linstow (1904) originally described from *E. albiventris* in Nigeria. This species has recently been recorded by Baylis (1928) from *Atelerix spicules* and *A. spinifex* in Nigeria. In this communication Baylis observes that *P. clausa* of Seurat is a synonym of *P. dispar*. He arrived at this conclusion after having re-examined the type-specimens of the latter. He points out that von Linstow's description and figures are inaccurate in several particulars and refers to the discrepancy between Seurat's and von Linstow's descriptions in regard to the length of the spicules. Baylis records that the length of the left spicules varies considerably, ranging from 0.3 to 0.5 mm.

3. *Physaloptera incurva,* von Linstow (1908) recorded as a parasite of *Erinaceus frontalis* (syn. *Aethechinus frontalis*) from the Kalahari region. This species is rather inadequately described by von Linstow as quoted by Ortlepp. Von Linstow's original communication is not available in South Africa. It is quite natural to expect that the specimens described by von Linstow would be identical with those collected by me from the same host.

The Identity of the Transvaal Specimens.—On comparing the measurements (Tables II, III and IV) of the locally collected specimens with the already described species from hedgehogs, it would appear that *P. clausa* of Seurat, *P. dispar* and *P. incurva* and the locally collected specimens are identical, and that a re-examination of *Physaloptera clausa* Rud., may prove *P. dispar* to be identical with it.

The examination of the few males present in my material seems to prove that too much significance should not be attached to: (1) the position of the various pairs of caudal papillae and (2) the character of the post-anal papillae as to whether certain pairs are always pedunculated or sessile. Baylis has shown that the length of the left spicule may vary considerably. Where *camera lucida* drawings of the spicules are given, it would appear essential to have both lateral and dorsal aspects figured. Baylis has rightly referred to the difficulty of determining the precise limits of the spicules in cleared specimens.

Remarks on Certain Structures in the Transvaal Specimens.—It should be stated that the specimens were probably not quite full-grown and this may account for slight differences in certain measurements (e.g. maximum diameter of body).

Ortlepp (1922) observes that he has failed to detect the presence of the additional external papillae recorded by a number of observers as present in the midline of the lip. In the specimens examined by me there is in the midline at the shoulder-like bulging of each lip a small papilla (*median cephalic papilla*) situated in a small depression. These median cephalic papillae are also present in specimens of *Physaloptera capensis*, described by Ortlepp (1922) for *Xerus setosus* (syn. *Geosciurus capensis*), South Africa, and in the specimens of a species of *Physaloptera* collected by the writer on the 28th May, 1929, from the stomach of a native dog and handed to Prof. H. O. Mönnig, who has described and designated them *Physaloptera canis*. The latter does not record the presence of the median cephalic papillae.

In some specimens the loosely attached cuticle forms a prepuce-like collar at the base of the lips. In others this bulging forward of the cuticle over the base of the lips was not evident and in these cases the surface of the cuticle in the region of the base of the lips appear studded with numerous minute elevations (Figure 1). This modification of the surface of the cuticle in this region is undoubtedly an adaptation for facilitating anchorage to the gastric mucosa when the cuticle is extended over the base of the lips.

The chief measurements of three males and five females are tabulated with the measurements of a male and a female of Seurat (1917) The still more immature specimens were not measured.

TABLE II.

COMPARISON OF THE CHARACTERS OF THE SPECIES OF *Physaloptera* RECORDED FROM HEDGEHOGS IN EUROPE AND IN AFRICA.

Species	*P. clausa* Rud. 1819.	*P. clausa* Rud. 1819.	*P. dispar* von Linstow, 1904.	*P. incurva*, von Linstow, 1908.	*Physaloptera* sp.
Authors	Ortlepp (1922)	Seurat (1917)	v. Linstow (1904)	v. Linstow (1908)	Le Roux
Hosts	*E. europaeus.*	*E. algirus.* *E. deserti.*	*E. albiventris.*	*A. frontalis.*	*A. frontalis.*
Locality	Europe	North Africa	Nigeria	Kalahari Desert	Transvaal
Length or body ♂	15 to 18 mm.	10·8 to 30 mm.	16·6 mm.	20 mm.	20–22 mm.
♀	30 to 50 mm.	21 to 52·5 mm.	25·0 mm.	47 mm.	33–36 mm.
M‸ximum breadth of body ♂	825μ–875μ	730μ	530μ	750μ	436–496μ
♀	1·3 to 1·6 mm.	1·350 mm.	950μ	1·58 mm.	672–864μ
Ratio of length of oesophagus to length of body ♂	1 : 5·4 to 1 : 5·6	1 : 4·8	1 : 4·9	1 : 7·6	1 : 5·3 to 1 : 5·9
♀	1 : 7·8 to 1 : 9	1 : 6·9	1 : 6·2	1 : 8	1 : 6 to 1 : 7·2
Ratio of length of muscular oesophagus to total length of organ—					
♂	1 : 7	1 : 8·3	—	—	1 : 7·8 to 1 : 8·8
♀	1 : 8·5	1 : 9·5	—	—	1 : 9·4 to 1 : 9·7
Ration of length of tail to length of body ♂	—	1 : 22	1 : 19	1 : 22	1 : 22 to 1 : 23
♀	1 : 45 to 1 : 55	1 : 54	1 : 26	1 : 235	1 : 63 to 1 : 73
Measurements of the spicules—Right	495 × 50μ	300–325μ	350μ	360μ	300 × 48–52μ
Left	740 × 33μ	275–360μ	620μ	570μ	320–500 × 32–40μ
Measurements of eggs *in uteri*	52 × 38μ	65 × 42μ	57 × 42μ	57 × 39μ	56–60μ × 30–32μ

TABLE III(A).

A comparison of the Measurements (in millimetrs) of a female of *P. clausa* Rud. of Seurat with those of five Specimens of the species of *Physaloptera* from *Aethechinus frontalis.*

Species	*P. Clausa.*	*Physaloptera* sp.				
Authors	Seurat, 1917.	Le Roux.				
Length of body	51·5	33·0	34·0	34·5	35·2	36·4
Maximum width of body	1·350	0·720	0·800	0·672	0·848	0·864
Distance of nerve-ring from anterior end	0·696	0·448	0·512	0·480	0·496	0·516
Distance of cervical papillae from anterior end—						
Right	1·130	0·672	0·816	0·728	0·780	0·992
Left	1·140					
Distance of excretory pore from anterior end	1·152	0·720	0·806	0·720	0·768	0·720
Distance of vulva from anterior end	8·415	4·100	4·800	5·107	4·300	4·420
Length of muscular oesophagus	0·780	0·496	0·560	0·480	0·544	0·563
Maximum width of muscular oesophagus	—	0·136	0·120	0·138	0·144	0·146
Total length of oesophagus	7·425	4·696	5·310	4·730	5·244	5·425
Maximum diameter of oesaphagus	—	0·320	0·304	0·320	0·336	0·328
Distance of anus from posterior end	0·950	0·480	0·560	0·480	0·560	0·496
Measurement of eggus *in utero*—						
Length	0·065	0·056	0·056	0·058	0·058	0·062
Breadth	0·042	0·030	0·030	0·032	0·032	0·030

TABLE III(B).

A Comparison of the measurements of a male of *P. clausa* Rud. of Seurat with those of the three specimens of a species of *Physaloptera* from *A. frontalis.*

Species	*P. clausa.*	*Physaloptera* sp.		
Authors	Seurat, 1917.	Le Roux.		
Length of body	26·7	20	21	22
Maximum width of body	0·730	0·480	0·496	0·486
Distance of nerve-ring from anterior end	0·530	0·400	0·400	0·400
Distance of cervical papillae from anterior end—				
Right	0·900	0·576	0·562	0·608
Left	0·905			
Distance of excretory pore from anterior end	0·995	0·592	0·576	0·622
Length of muscular oesophagus	0·600	0·416	0·456	0·435
Maximum diameter of muscular oesophagus	—	0·108	0·102	0·102
Total length of oesophagus	4·820	3·666	3·556	4·135
Maximum diameter of Oesophagus	—	0·224	0·232	0·210
Length of spicules—				
Right	0·300	0·300	0·300	0·300
Left	0·360	0·384	0·320	0·500
Distance of anus from posterior end	1·210	0·880	0·912	0·896

MONILIFORMIS MONILIFORMIS (BREMSER, 1811).

Two species of *Moniliformis* Travassos, 1915 have hitherto been recorded from hedgehogs. Southwell and Macfie (1925) describe *Moniliformis erinacei* from the hedgehog (*Erinaceus europaeus*) at Accra, West Africa. Von Linstow (1904) describes *Echinorhynchus cestodiformis* from the Nigerian hedgehog (*Erinaceus albiventris.*) Van Cleave (1924) having examined the type of von Linstow's species pronounced it to be identical with the type species *Moniliformis moniliformis* (Bremser 1877), which has *Erinaceus europaeus* from Europe as its type host. Southwell and Macfie examined specimens of the type species collected from *Mus rattus* and *Mus norvegicus* at Liverpool, West Africa (Freetown and Accra), South America (Manaos), and Australia (Townsville), from *Cricetomys gambianus* at Accra, and one specimen from *Homo sapiens* at British Honduras. Subramanian (1927) describes *Moniliformis spiralis* from the intestine of *Nesopia bengalensis* at Rangoon.

The measurements of the species from the South African hedgehog are tabulated with those of others (see Table IV). From a study of these measurements it is evident that the specimens from the local hedgehog have certain measurements in common with the type species and others in common with *Moniliformis erinacei*, Southwell and Macfie (1925), of which only a solitary pair (male and female) was examined by the authors.

It is evident from the description of *M. moniliformis* that the measurements of the same structure vary within very wide limits. The measurements quoted for the species from the local hedgehog are of specimens preserved in 10 per cent. formalin and cleared in lacto-phenol. Specimens were dissected for the determination of the exact length of the lemnisci, which differed in length even in the same specimen. They reach the greatest length in the more matured individuals.

Southwell and Macfie (1925) list as synonyms of *Moniliformis moniliformis* the species:—

1. *Echinorhynchus moniliformis*, Bremser, 1815.
2. *Gigantorhynchus moniliformis* of Railliet *et al.*
3. *Hormorhynchus moniliformis* of Ward, 1917.
4. *Echinorhynchus cestodiformis*, v. Linstow, 1904.
5. *Gigantorhynchus cestodiformis* of Porta.
6. *Moniliformis cestodiformis* of Travassos.

Baylis (1929) records *M. moniliformis* as a parasite of rats, mice and squirrels and occasionally of man and dog. As probable synonyms he lists the species:—

1. *Echinorrhynchus* grassi Railliet, 1893 from a dog in Sicily.
2. *Echinorrhynchus canis* Porta, 1914 from a dog in Brazil.
3. *Echinorrhynchus hominis* Leuchart, 1876 from a human in Prague.

The differences between the specimens of *Moniliformis* collected from the various mammals are so insignificant that they should probably all be regarded as members of the same species.

TABLE IV.

A COMPARISON OF THE CHARACTERS AND MEASUREMENTS (IN MILLIMETRES) OF SPECIMENS OF *Moniliformis* FROM MAMMALS.

Species	*M. spiralis*	*M. moniliformis*	*M. erinacei*	*M. cestodiformis*	*M. moniliformis*	*M. moniliformis*
Authors	Subramanian (1927)	Southwell and Macfie (1925)	Southwell and Macfie (1925)	v. Linstow (1904)	Baylis (1929)	Le Roux
Hosts	*Nesokia bengalensis*	*Homo Sapiens, Mus rattus, M. norvegicus, Cricetomys gambianus*	*Erinaceus europaeus*	*Erinaceus albiventris*	Man, dog, rats, mice, squirrels	*Aethechinus frontalis* (Syn. *Erinaceus frontalis*)
Length of body ♂	33–44	5·5–86	85	115	40–80	65–90
♀	46	7 –239	110		70–110	100–140
Maximum breadth of body ♂	0·78	—	1·6	2·17	1–7·5	1·7–2·0
♀			1·5			1·6–1·8
Measurements of lemnisci	3·71–3·05	2·40–8·76	7–8 × 0·2	1·70	—	10–22 × 0·16–0·40
Measurements of proboscis	0·21–0·45 × 0·12–0·19	0·50–0·67 × 0·2	0·40–0·50 × 0·20	0·47 × 0·20	—	0·64–0·96 × 0·32–0·40
Measurements of testes	1·25–1·54 × 0·29–0·39	0·201–4·0 × 0·120–0·96	5·0 × 1·3	—	—	2·60–4·20 × 0·8–1·10
Measurements of eggs	0·084–0·092 × 0·035–0·046	0·109–0·137 × 0·057–0·063	0·092 0·051	0·085 0·049	0·124–0·127 × 0·071–0·074	0·102 × 0·055 to 0·124 × 0·064
Number of antero-posterior rows of hooks	10–13	12–16	18	14	14	18
Number of hooks in each row	6–7	10–12	7–8	8	15	9

LITERATURE.

BAYLIS, H. A. (1928). On a collection of Nematodes from Nigerian Mammals (chiefly Rodents). *Parasit.*, Vol. 20, No. 3, Oct., pp. 301-302.

BAYLIS, H. A. (1929). *A Manual of Helminthology Medical and Veterinary.* Baillière, Tindall & Cox, London.

BAYLIS, H. A., AND DAUBNEY, R. (1926). *A Synopsis of the Families and Genera of Nematoda.* Richard Clay & Sons, Ltd., Bungay, Suffolk, England.

HALL, M. C. (1914). A New Nematode, *Rictularia splendida*, from the coyote, with notes on other coyote parasites, *Proc. U.S. Nat. Mus.*, Vol. 46, pp. 73-84.

HALL, M. C. (1916). Nematode Parasites of Mammals of the Orders *Rodentia, Lagomorpha*, and *Hyracoidea*, *Proc. U.S. Nat. Mus.*, Vol. 50, p. 258.

HALL, M. C., AND WIGDOR, M. (1918). A *Physaloptera* from the Dog, with a Note on the Nematode Parasites of the Dog in North America, *Jnl. Amer. Vet. Med. Assn.*, Vol. 53, N.S. Vol. 6, No. 6, pp. 733-744.

HOEPPLI, R. (1929). *Rictularia tani* n. sp. ein Parasit des Rattendarmes. *Centralbl. f. Bakt. Paras. u. Infektionk.* Orig. Bd. 110, Heft 1/3 Jan., pp. 75-78.

JOHNSTON, T. H. (1914). Second Report on the *Cestoda* and *Acanthocephala* collected in Queensland, *Ann. Trop. Med. and Paras.*, Vol. 8, No. 1, pp. 105-112.

MASSINO, B. (1925). Ein neuer Nematode des Hundes; *Rictularia cahirensis* Jagerskiold 1909, *Berl. Tierartz. Wochenschr.*, Vol. 41, No. 5, pp. 67-69.

MÖNNIG, H. O. (1929). *Physaloptera canis*, n. sp. A New Nematode Parasite of the Dog, *15th Ann. Rept. Dir. Vet. Services*, Pretoria, Oct., pp.329-333.

ORTLEPP, R. J. (1922). The Nematode genus *Physaloptera* Rud., *Proc. Zool. Soc.*, London, June, pp. 999-1107.

SCHULZ, R.-Ed. (1927). Zur Kenntnis der Helminthenfauna der Nagetiere der Union S.S.R. *Oeuvres de l'institut* d'et de la médécine Vétérinarie Expérimentale à Moscou, Vol. IV, No. 2, pp. 36-65.

SEURAT, L. G. (1915). Sur les Rictulaires des Carnivores du Nord-Africain et les Affinités du genre *Rictularia*, *C.R. Soc. Biol.*, Vol. 78, p. 318.

SEURAT, L. G. (1917). Physalopteres des mammifères du Nord-Africain, *C.R. Soc. Biol.*, Vol. 80, p. 43.

SEURAT, L. G. (1920). Histoire Naturelle des Nematodes de la Berberie, Algiers.

YORK, W., AND MAPLESTONE, P. A. (1926). *The Nematode Parasites of Vertebrates.* J. & A. Churchill, London.

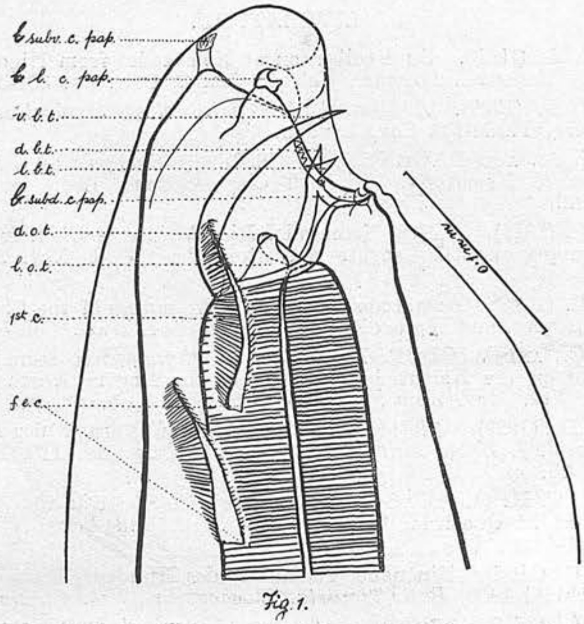


Fig. 1. Lateral view of the anterior extremity. *R. aethechini.*

d.b.t. = dorsal buccal tooth; d.o.t. = dorsal oesophageal tooth; l.b.t. = lateral buccal tooth; l.i.c. pap. = left lateral cephalic papilla; l.o.t. = lateral oesophageal tooth; l. subv. c. pap. = left subventral cephalic papilla; l. subd. c. pap. = left subdorsal cephalic papilla.

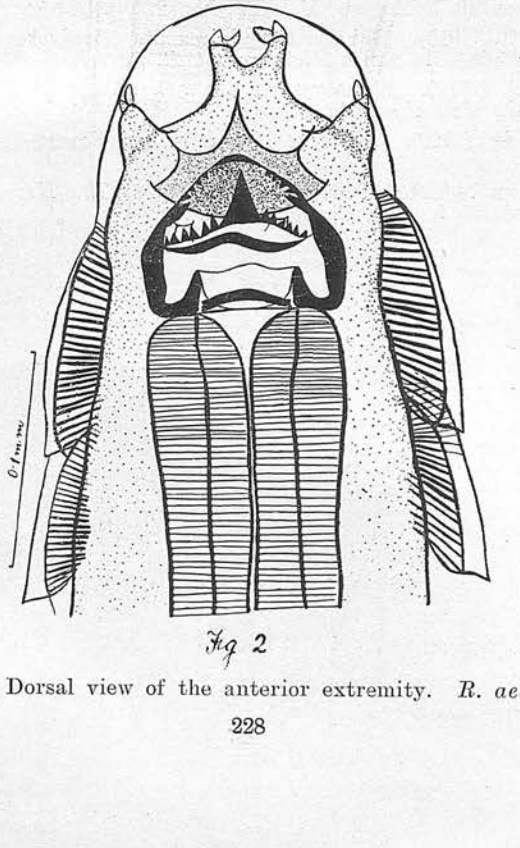


Fig. 2. Dorsal view of the anterior extremity. *R. aethechini.*

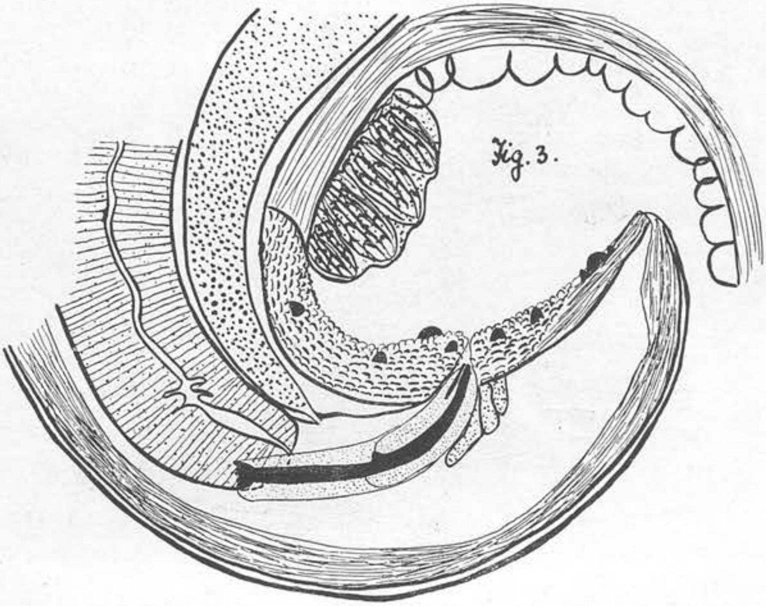


Fig. 3. Posterior extremity of the male. *R. aethechini.*

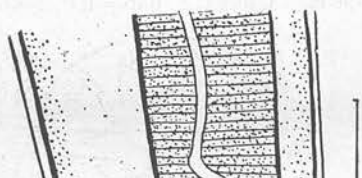
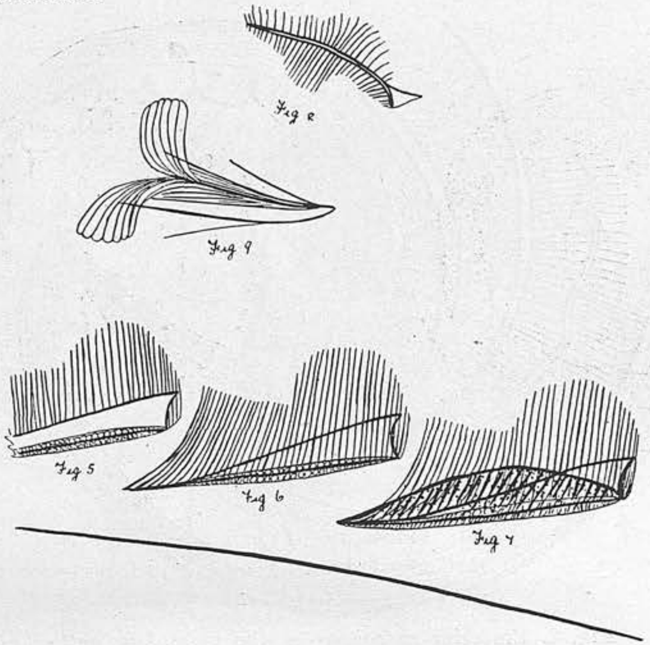
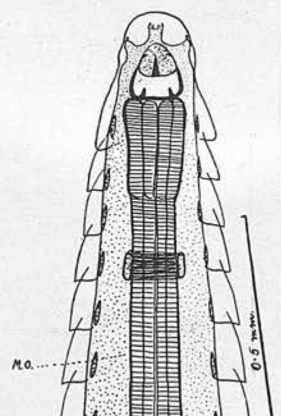


Fig. 4. Posterior extremity of the female. *R. aethechini.*



Figs. 5-9. Differently shaped cuticular appendages. *R. aethechini.*



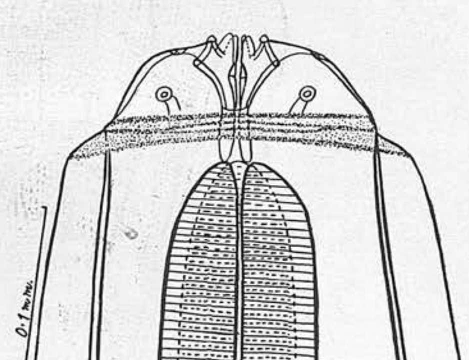


Fig. 10. Dorsal view of the anterior extremity showing the cuticular appendages (combs) overlapping. *R. aethechini.*

M.O. = Muscular oesophagus. G.O. = Glandular oesophagus.

Fig. 11. Laterial view of anterior extremity. *Physaloptera* sp.

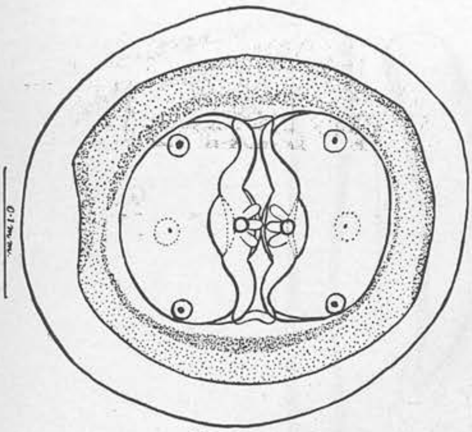


Fig. 12

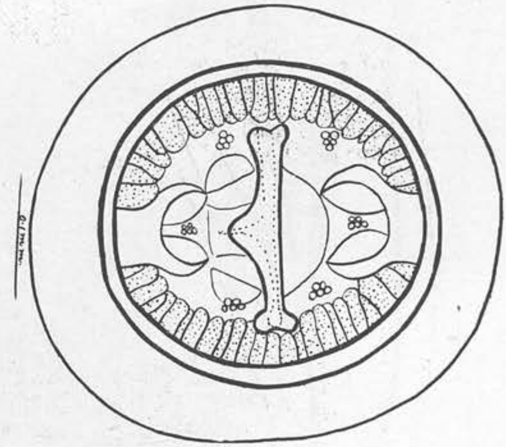


Fig 13

Fig. 12. Anterior of the cephalic extremity. *Physaloptera* sp.

Fig. 13. Transverse section through cephalic extremity just posterior to the lips. *Physaloptera* sp.

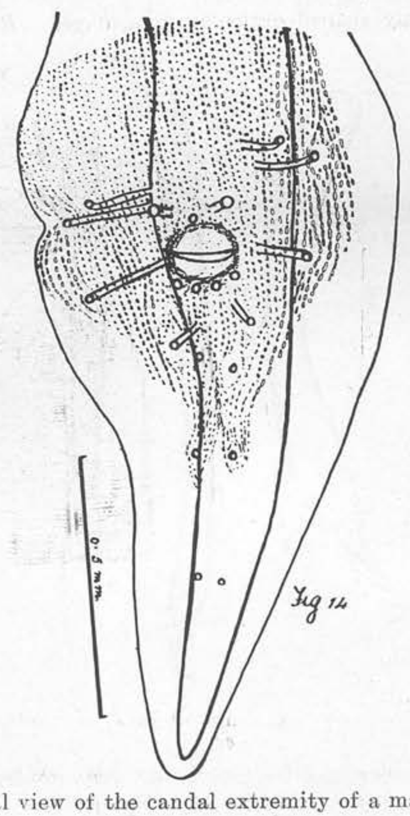


Fig. 14. Ventral view of the candal extremity of a male. *Physaloptera* sp.

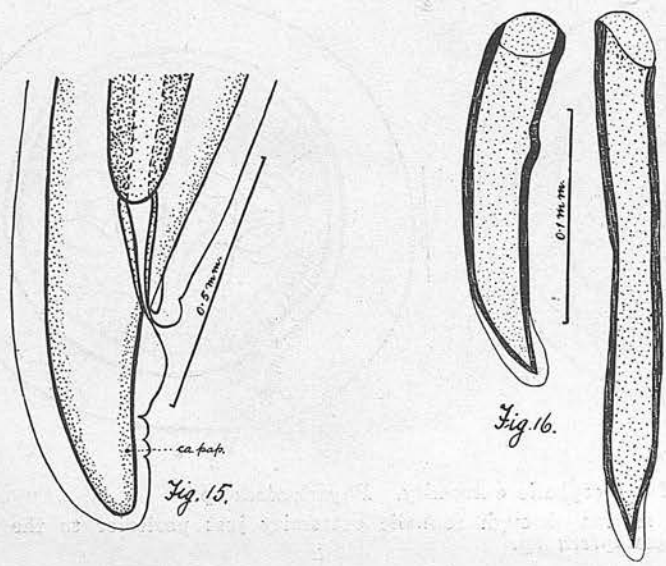


Fig. 15. Lateral view of the candal extremity of a female. *Physaloptera* sp.
Fig. 16. Left and right spicules. *Physaloptera* sp.

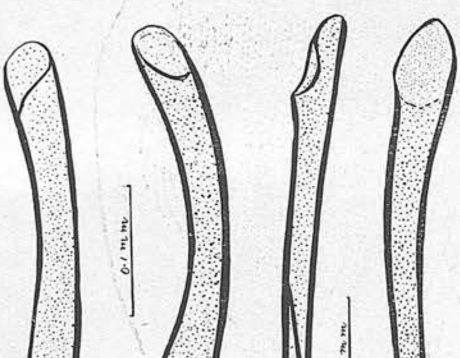


Fig. 17. The same left spicules in different views. *Physaloptera* sp.
Fig. 18. Right spicules from two males. *Physaloptera* sp.

Article No 11.

16th Report of the Director of Veterinary Services and Animal Industry, Union of South Africa, August, 1930.

On Two New Helminths from the Abomasum of the Bushbuck in Zululand, Natal.

By P. L. LE ROUX, B.Sc. (Edin.), M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

INTRODUCTION.

In August, 1929, the writer spent a week in Zululand with a ranger who is shooting game under the direction of Mr. R. H. Harris, Director of Operations, Tsetse Fly Control. During this short stay there were facilities for the collection of parasites from buck shot in an area south of the White Umfolozi River. Most of the animals examined were relatively free of helminths, for from some, only three or four specimens were obained, while the majority harboured no macroscopic helminths whatever.

The bushbuck (*Tragelaphus sylvaticus*) yielded two species new to science, these being from the abomasum. For the one species, which is a member of the genus *Ostertagia* Ransom 1907, the name *Osteragia harrisi*, sp. nov. is proposed in honour of Mr. Harris who assisted me in many ways. The females of the other species resemble those of *H. contortus* so closely that only a microscopic examination allows of a differentiation from members of the genera *Haemonchus* Cobb, 1898, and *Mecistocirrus* (Railliet and Henry, 1912), Neveu-Lemaire, 1914. Since the specimens of this species could not be allocated to any known genera of the sub-family *Trichostrongylidae* Leiper, 1908, the name *Ashworthius pattoni* gen. et sp. nov. is proposed in honour of Prof. J. H. Ashworth and Dr. W. S. Patton, my past teachers of Parasitology at the University of Edinburgh. In addition to these two species the host also harboured specimens of *Haemonchus vegliai* Le Roux, 1929, which has the Cape Kudu (*Strepsiceros strepsiceros* as type host and the Transvaal as type locality. Curson (1928) does not list any helminths from the bushbuck in Zululand; but Mönnig (1928) mentions *Cordophilus sagitta* and *Oesophagostomum columbianum* as parasiting this antelope.

It is indeed a great pity that adequate provision could not be made for the collection of helminths from the wild ruminants now being shot outside the boundaries of the old Umfolozi Game Reserve, where the unique Southern White Rhinoceros is also to be found. It would have been of value to know exactly the degree to which game may be infested with ecto- and endo-parasites.

O'Roke (1927) has sounded a warning regarding parasitism and fauna conservatism. He shows that game protection societies are primarily concerned with the preservation of wild animals against gun-powder and lead, but that very little attention is paid to the vital requirements of the animals or their protection against parasites. He adds: "Food and water, shelter and cover, and protection from enemies are the factors usually considered in planning for the conservation of wild life. The important but little understood questions of parasitism are beginning to command the attention of naturalists and biologists. The parasitologist can render valuable service to game commissions and wild life institutes through his knowledge of the ways of parasites."

ASHWORTHIUS gen. nov.

Generic Diagnosis.—Trichostrongylinae: Body filiform, head relatively large, buccal capsule rudimentary, buccal cavity small and armed with a stout tooth originating from the dorsal sector of the oesophagus; cephalic papillae present, cervical papillae prominent. *Male*: copulatory bursa with well developed lateral lobes, and a prominent dorsal lobe; bursal formula:—ventro-ventral and latero-ventral arise from a fairly long common trunk; ventro-ventral about half the length and thickness of the latero-ventral; extero-lateral ray is the longest and best developed ray in the lateral lobe and arise in common with the medio-lateral ray from a well developed common trunk which in turn shares a very stout trunk in common with the postero-lateral ray; externo-dorsal ray long but slender and lies parallel to the postero-lateral which diverges distally from the other lateral rays; dorsal ray well developed, terminating in four digits of which the inner two are the best developed. Spicules relatively short, with crests and protuberances (Figures 5 and 6.) Gubernaculum apparently absent. *Female*: Vulva in the posterior half of the body. Eggs segmenting when oviposited.

ASHWORTHIUS PATTONI, gen. et. sp. nov.

One male and five females were collected, preserved in glycerine alcohol and examined, and measured after decolourising in lactophenol. The chief measurements of the male and females are shown in Table I.

Characters common to Male and Female.—The buccal cavity is better developed than in either *Haemonchus* Cobb, 1898 or *Mecistocirrus* (Railliet and Henry, 1912), Neveu-Lemaire, 1914, and appears to be furnished with an extremely poorly developed buccal capsule (Figures 1 and 2). The buccal cavity faces slightly dorsally and is armed with a rather stout buccal lancet bent at right angles on itself and with the sharply pointed free extremity directed dorsally and projecting beyond the edge of the buccal cavity. This buccal lancet, perhaps more correctly termed dorsal gutter, measures approximately 23-25μ along its convex border. It is attached to the dorsal half of the oesophagus by means of two roots, triangular in outline in a dorsal view, but roughly rectangular in a lateral view. After attaining a height of 16μ the buccal lancet bends sharply dorsally. This dorsally pointing portion measures 8-10μ in length. The tooth has a maximum lateral diameter of 10μ. Along the ventral border runs a groove into which the dorsal cephalic gland opens. The head is studded with the usual six cephalic papillae. The median head papillae are slightly more anteriorly situated than the others. Freshly collected specimens are of a darker colour than the common abomasal worms of sheep and cattle. The cuticle bears fine cross striations. Longitudinal striations, as recorded for other Trichostrongylidae, are present.

Male Characters.—The copulatory bursa (Figure 3), consists of two prominent lateral lobes and a well developed symmetrical dorsal lobe measuring 626μ by 180μ. The dorsal ray supporting the dorsal lobe has a strongly developed stem measuring 144μ in length and divides posteriorly into two branches, each of which bifurcates almost immediately into a short, stout inner branch and a less strongly developed outer branch. The approximate arrangement of the rays supporting the lateral lobes are as drawn (Figure 4). The inner surfaces of the lateral lobes are furnished with bosses not unlike those met with in *H. contortus* and *M. digitatus*. The free borders of the lateral lobes are crenated. The prebursal papillae, rather short and inconspicuous, are situated about 156μ in front of the bursa. Just anterior to them the cuticle is inflated laterally. The genital cone (Figure 7) is well developed with a rounded caudal extremity. In lateral view it bears a prominent swelling on its ventral surface. The genital appendages are well developed. The outline of the spicules varies somewhat when viewed dorsally, laterally or medially. In dorsal and ventral views they appear to be furnished with lateral projections at a point about 48μ from the posterior extremity which consists of two parts slightly overlapping each other and expanded ventrally. A gubernaculum appears absent.

Female Characters.—Macroscopically the females would be mistaken for specimens of *H. contortus*. The ovaries are twisted round the intestine and produce the barber's pole appearance recorded as characteristic for the wireworm of sheep. The arrangement of the genitalia is as in the members of the genus *Haemonchus* except for the absence of a linguiform process or cuticular swellings (Figure 8) in the neighbourhood of the vulva, which takes the form of a transverse slit. Posteriorly the body terminates in an acutely pointed tail (Figure 9).

Type host: Adult male bushbuck (*Tragelaphus sylvaticus*). *Habitat*: Abomasum. *Type locality*: Zululand, south bank of the White Umfolosi River. *Type specimens and co-types*: Will be deposited in the Helminthological collection at Onderstepoort.

TABLE I.

Measurements (in Millimetres) of *Ashworthius pattoni* gen. et sp. nov.

	Male.	*Females.*
Length	17·0	20·0 –24·0
Lateral width of head	0·050	0·045– 0·052
Thickness at level of cervical papillae	0·115	0·112– 0·138
Thickness at base of oesophagus	0·190	—
Thickness in front of copulatory bursa	0·282	—
Thickness at level of vulva	—	0·308– 0·354
Length of oesophagus	1·39	1·39 – 1·62
Width of oesophagus anteriorly	0·028	0·035– 0·037
Minimum width of oesophagus	0·022	0·028– 0·032
Maximum width of oesophagus	0·144	0·160– 0·170
Anterior end to cervical papillae	0·385	0·324– 0·462
Anterior end to excretory pore	0·278	0·262– 0·338
Length of spicules	0·400	—
Vulva to anus	—	3·08 3·88
Anus to posterior end	—	0·539– 0·554
Caudal papillae to posterior end	—	0·162– 0·200
Measurements of ova *in utero*	—	0·094–0·098 x 0·048– 0·050

OSTERTAGIA HARRISI sp. nov.

Two males (one damaged) and seven females were collected from a portion of abomasum and preserved in 10 per cent. formalin. Having been kept in cold formalin the specimens are much coiled.

Characters common to both Sexes.—The opening of the small mouth cavity faces anteriorly. The cuticle of the head is slightly dilated (Figure 10), and followed by a constriction. The cuticle is marked by rather fine cross striations and more prominent longitudinal ridges which, under high magnification, have a beaded appearance as defined by Ransom (1907) for the genus *Ostertagia*. These longitudinal striations decrease to a number as the cephalic end of the worm is approached and only half their number proceed anteriorly beyond the cervical papillae. The sharply pointed cervical papillae are not placed laterally, but slightly nearer the mid-ventral line. They are well developed, and appear to be chitinised. The oesophagus is of the usual *Ostertagia* type and the cervical nerve ganglion is situated a little in front of the cervical papillae.

Male Characters.—The copulatory bursa (Figure 11) is of the usual type and about twice as broad as long. The arrangement of the rays supporting the lobes of the bursa are as figures (Figure 11). The spicules are truncated at the tip and appear approximately as drawn [Figure 12 (*a-c*)].

Female Characters.—The vulva is a transverse slit covered with or without a prominent cuticular flap (see Figure 16). The anus is close to the tip of the tail which in all specimens was curled ventrally as figured. The tip of the tail is inflated. The muscular parts of the ovejectors are well developed. Eggs were only present in the anterior uterus. The posterior half of the genitalia contains no eggs and appears atrophied (Figure 13.)

Type host—a young bushbuck ram. *Habitat*—abomasum. *Locality*—Zululand, on the south bank of the White Umfolozi River. *Type specimens and co-types*—Will be deposited in the Helminothological collection at Onderstepoort.

TABLE II.

Measurements (in Millimetres) of *Ostertagia harrisi* sp. nov.

	Males.	*Females.*
Length	3·8	4·6 – 6·3
Lateral diameter of head	0·016	0·016– 0·017
Thickness in front of bursa	0·89	
Thickness at vulva	—	0·091– 0·114
Thickness at anus	—	0·038– 0·042
Thickness at base of oesophagus	0·057	0·055– 0·070
Length of oesophagus	0·448	0·450– 0·520
Maximum diameter of oesophagus	0·032	0·032– 0·040
Anterior end to cervical papillae	0·175	0·200– 0·230
Anterior end to excretory pore	0·169	0·195– 0·225
Vulva to anus	—	0·380– 0·415
Anus to posterior end	—	0·096– 0·112
Length of spicules	0·155–0·160	
Measurements of eggs *in utero*	—	(0·070 x 0·044) – (0·083 x 0·048)

REFERENCES.

ABYLIS, H. A. (1929). Two new Species of Cooperia (Nematode) from Australian Cattle. *Ann. and Mag. Nat. Hist.*, Ser. 10, Vol. 4, pp. 529-533.

BAYLIS, H. A., AND DAUBNEY, R. (1926). *A Synopsis of the Families and Genera of Nematoda.* Richard Clay & Sons, Ltd., Bungay, Suffold.

CAMERON, T. W. M. (1923). Studies on two new genera and some little-kncwn species of the Nematode family *Trichostrongylidae* Leiper. *Jl. Helm.*, Vol. 1, pp. 71-96. London.

CANAVON, W. P. N. (1929). Nematode Parasites of Vertebrates in the Philadelphia Zoological Garden and vicinity. I. *Parasit.*, Vol. 21, pp. 63-102.

CRAM, E. B. (1925). *Cooperia bisonis*, a new Nematode from the Buffalo. *Jl. Agric. Res.*, Washington, Vol. 30, No. 6, pp. 571-573.

CURSON, H. H. (1928). Metazoan Parasites from Zululand. *S. Afric. Jl. Nat. Hist.*, Vol. 2, pp. 181-187.

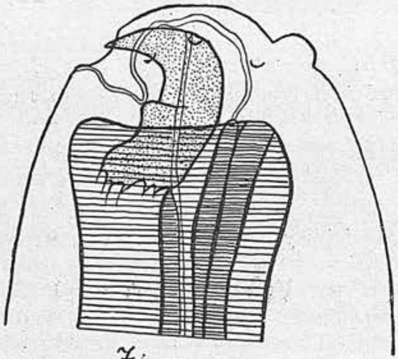
MÖNNIG, H. O. (1928). Check List of the Worm Parasites of Domesticated Animals in South Africa. *13th and 14th Repts., Dir. Vet. Educ. and Res.*, Dept. Agric., U. S. Africa, pp. 801-837.

O'ROKE, E. C. (1927). The Relation of Parasitism to Wild Life Conservation. *Jl. Parasit.*, Vol. 14, p. 135.

RANSOM, B. H. (1911). The Nematodes Parasitic in the Alimentary Tract of Cattle, Sheep, and other Ruminants. *U.S. Dept. Agric., Bur. Anim. Ind.*, Bull. 127. Washington.

TRAVASSOS, L. (1921). Contribucões para õ conhecimento da fauna helmintolojica brasileira. XIII. Ensai monografico da familia Trichostrongylidae Leiper, 1909. *Mem. Inst. Oswaldo Cruz*, Vol. 13, No. 1, pp. 5-140.

YORKE, W., AND MAPLESTONE, P. A. (1926). *The Nematode Parasites of Vertebrates.* J. & A. Churchill, London.



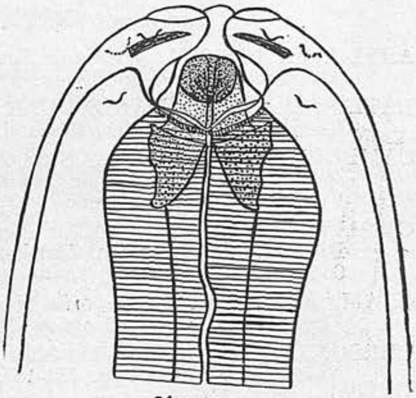


Fig. 1. Lateral view of cephalic extremity. *A. pattoni* sp. nov.
Fig. 2. Dorsal view of cephalic extremity. *A. pattoni* sp. nov.

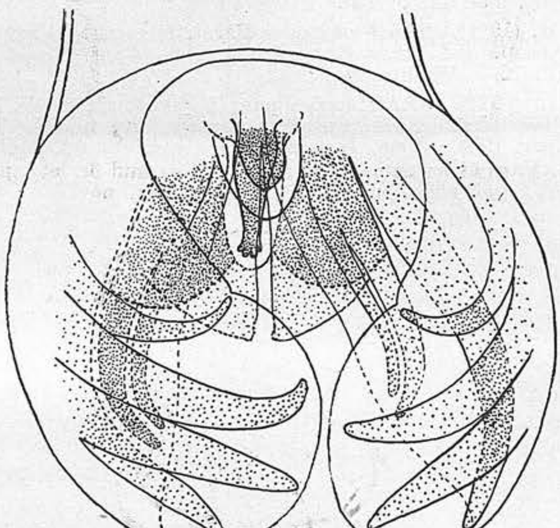


Fig. 3. Ventral aspect of caudal end of male. *A. pattoni* sp. nov.

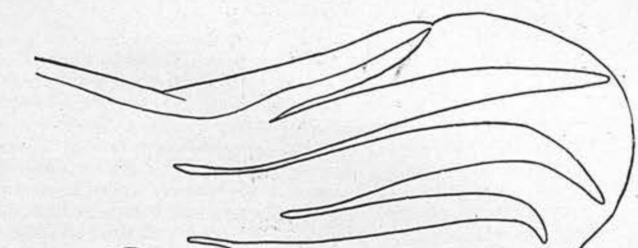
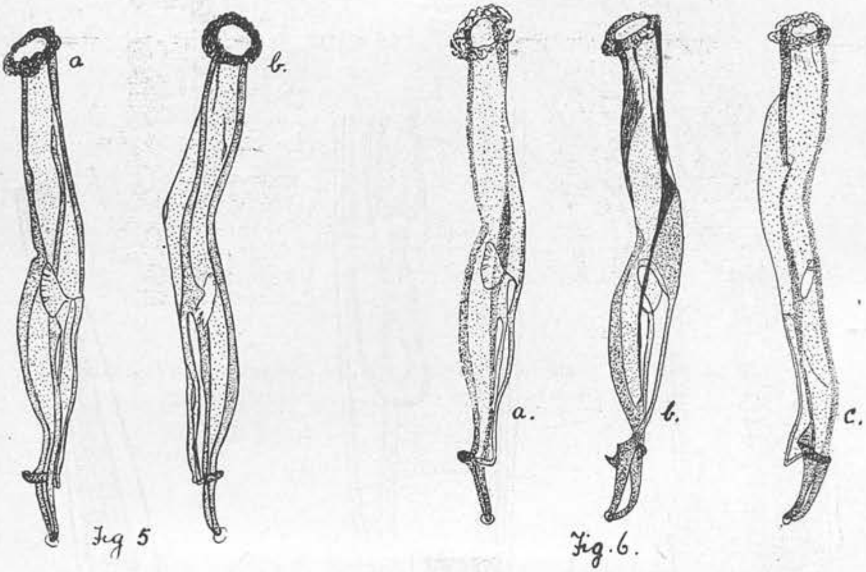


Fig. 4. Ventral aspect of left lobe of copulatory bursa. *A. pattoni* sp. nov.



Figs. 5 and 6. Various aspects of the spicules. 5a and 6a left spicule. 5b and 6c right spicule. *A. pattoni* sp. nov.

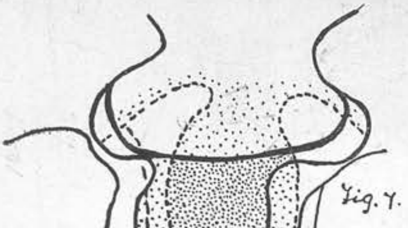


Fig. 7. Ventral view of genital cone and dorsal lobe of bursa. *A. pattoni* sp. nov.

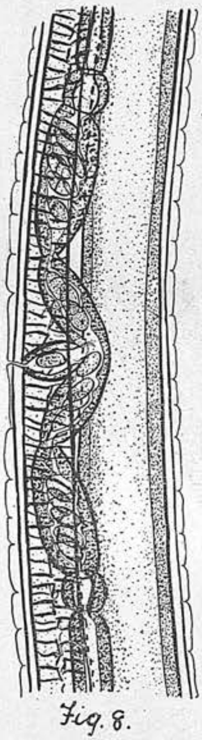


Fig. 8.

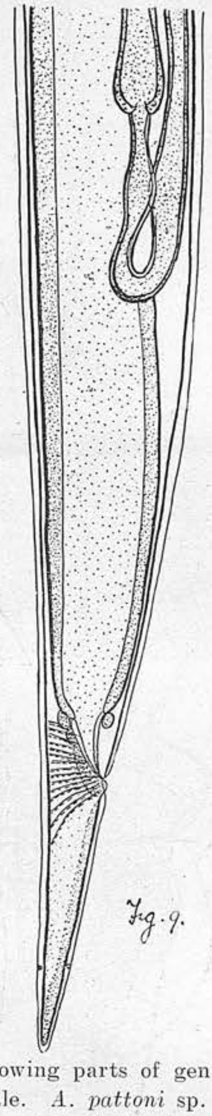


Fig. 9.

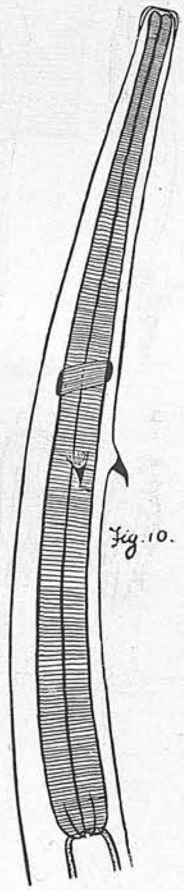


Fig. 10.

Fig. 8. Portion of female, showing parts of genitalia. *A. pattoni* sp. nov

Fig. 9. Posterior end of female. *A. pattoni* sp. nov.

Fig. 10. Anterior end of a female. *O. harrisi* sp. nov.

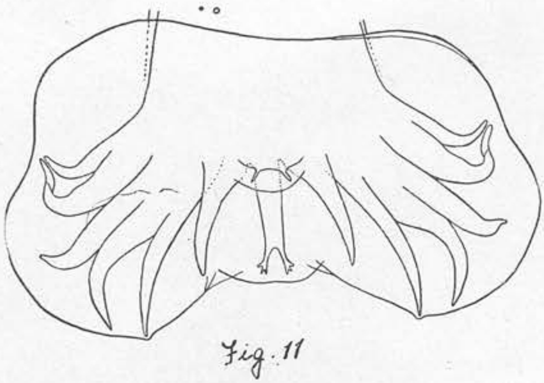
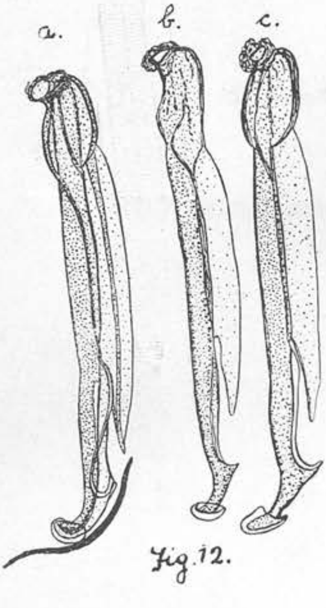


Fig. 11. Ventral aspect of the copulatory bursa. *O. harrisi* sp. nov.



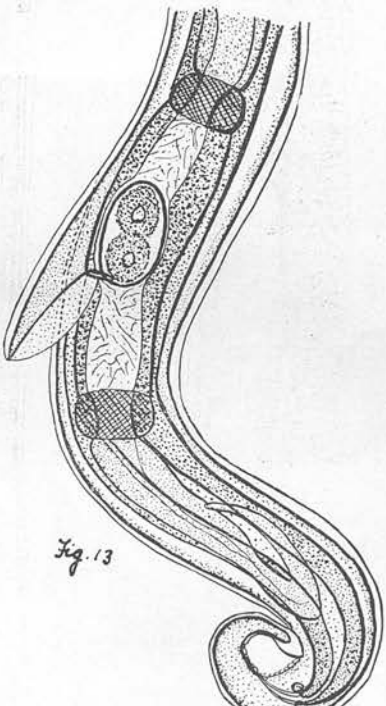


Fig. 12. *a*. Lateral view of left spicule and gubernaculum. *O. harrisi* sp. nov.
b. Right spicule.
c. Left spicule.

Fig. 13. Posterior extremity of female. *O. harrisi* sp. nov.

Article No. 12.

16th Report of the Director of Veterinary Services and Animal Industry, Union of South Africa, August, 1930.

A Preliminary Communication on the Life Cycle of *Cotylophoron Cotylophorum* and its Pathogenicity for Sheep and Cattle.*

By P. L. LE ROUX, B.Sc. (Edin.), M.R.C.V.S., Veterinary Research Officer, Onderstepoort.

WITHIN the last few months I had the opportunity of investigating two serious outbreaks of paramphistomiasis amongst sheep in the Orange Free State. These investigations and subsequent research proved that the immature stages of the paramphistome *Cotylophoron cotylophorum* (Fischoeder, 1901), Stiles and Goldberger, 1910, is most pathogenic for sheep and that the paramphistomes can no longer be regarded as the innoxious parasites that they were once considered to be.

THE OUTBREAKS INVESTIGATED.

The first farm to be visited was " Breezy Brae " near Arlington. The owner here lost about 30 per cent. from a flock of approximately 275. These sheep were running in a camp together with some native-owned cattle and had to drink from a rather muddy natural pool. The muddiness of the pool must be attributed to the presence of the cattle that wade well into the water when coming to drink. The examination of this pool proved that it was harbouring thousands of snails, members of a species of *Bulinus*. The species is probably identical with *Bulinus schakoi* (syn. *Isidora schakoi*) from which Cawston (1918), described *Cercaria frondosa*. Faust's (1919) description of this cercaria holds for the cercariae which proved to be the larval forms of *Cotylophoron cotylophorum*.

The sheep on autopsy had no adult or immature paramphistomes in the rumen but sexually immature forms were present in the abomasum and the rest of the alimentary tract posterior to it. They were most numerous in the duodenum and some were also passed in the soft black faeces. The affected animals were at the time of my visit suffering from a most foetid diarrhoea.

Prior to my arrival at the farm the sheep had been removed for some days from the camp where they took ill, because the water was on account of its turbidity regarded as unsuitable for consumption and declared to be the cause of the trouble. The presence of snails was evidently overlooked.

Six animals were bought and railed to Onderstepoort for further investigation. On their arrival at the institute one was killed and immature paramphistomes were recovered only from the abomasum

* Paper read at the Annual Meeting of the S.A. Veterinary Medical Association held at Pretoria on the 5th August, 1929.

and the intestines. To ascertain whether these trematodes were normal parasites of sheep and goats, portions of the duodenum, with parasites attached, were fed to two boer goat kids and three merino lambs born in the small experimental camps on this station and therefore free of infection. One of the kids was killed a week later and sexually immature paramphistomes were recovered from its abomasum and duodenum. One of the lambs, killed a fortnight after the kid, was found to harbour specimens in the rumen and a very few in the abomasum and duodenum. Another lamb killed six weeks after infection harboured specimens only in the rumen. One of the originally introduced sheep was killed on the same day and thousands of specimens were recovered only from the rumen where they were found attached, and closely crowded together.

Five of the sheep were bled for the determination of the blood calcium and phosphorus, and the analysis showed that the calcium content of the blood was much reduced. This reduction in the amount of the blood calcium probably accounts for the presence of the large quantities of sand observed in the abomasum and passing into the duodenum of the affected sheep. The farmers, however, assured me that the first animals that died had no sand in them and there is no reason to disbelieve them. I have often observed sand and other foreign material (coal cinders, granite gravel, small pebbles, etc.) in the rumen and abomasum of sheep suffering from anaemia due to haemonchosis and fascioliasis and in both these diseases the amount of calcium in the blood was appreciably reduced below normal. The blood of the sheep suffering from paramphistomiasis showed a further fall of blood calcium subsequent to the administration of from 4 to 8 c.c. carbon tetrachloride.

The history of the second outbreak investigated is interesting in that cattle seem to have infected the snails. Mr. Frank Hobbs of the farm "Haldon," Petrus Steyn, lost approximately 50 per cent. of a flock of 300 sheep turned into a camp in May when he removed the cattle that had run there since December, 1928. The sheep showed a loss of condition after having been in the camp for about sixteen days. He lost a few and thought nothing of it until the deaths rose to four and five a day when he reported the matter to an officer of the Division. From the material submitted by the farmer it was evident that he was losing stock from paramphistomiasis and the farm was visited and several autopsies held. Local inquiries confirmed my suspicions that farmers must occasionally lose heavily from this malady. One old farmer assured me that vleis (marshy grounds) are apt to kill sheep in the beginning of winter, especially if there had been plenty of rain during the summer. As oesophagostomiasis is not severe, and liver flukes are unknown in that area, it must be assumed that these farmers have in the past lost sheep from paramphistomiasis.

In years gone by the pathogenicity of the paramphistomes has evidently been overshadowed by the presence of other helminths or poisonous plants. If Mr. Hobbs' sheep had been running on *Cucumis* sp. infested lands, this plant would undoubtedly have been pronounced the lethal agent. I may perhaps mention that Mr. Hobbs had one flock of sheep on a land with *Cucumis* abundant, and yet he has not lost a sheep there.

Most veterinary parasitology textbooks consider paramphistomes as non-injurious parasites. Some, however, believe that they may be harmful while others add that paramphistomes have occasionally been suspected of being harmful. Wooldridge mentions that these trematodes have been reported as pathogenic from Australia. In South Africa the Veterinary Division has always considered them as of little importance and farmers have been informed that they are not very harmful. In the situation (rumen) in which they are usually observed, they are undoubtedly not very injurious if at all. Immature paramphistomes from the duodenum of cattle and sheep have been reported from different parts of South Africa and from India. The Onderstepoort helminthological collection contains specimens collected from different parts of the Union. When in 1925 I recorded their presence in trek oxen dying on the Empangeni Townlands, the then Director of Veterinary Education and Research, Onderstepoort, informed me that he had had specimens from various parts of the country. There are specimens here collected from sheep and presented by Mr. Simson (1926), Government Veterinary Officer, Queenstown. Mr. Henderson, Government Veterinary Officer, Kokstad has last year and this year submitted specimens from sheep in his area.

The material from cattle consists of specimens submitted by the Principal Veterinary Officer, Basutoland, from cattle at Maseru, and specimens collected from cattle at Onderstepoort and at Empangeni, Zululand. In cattle, as in sheep, there is a diarrhoea, which is more profuse in bovines and has to be differentiated from Johne's disease and certain other forms of parasitic diarrhoea.

In an article headed " Some Problems in Sheep Diseases," Baldrey (1906), from India, discusses " Gillar " and points out that clinically it somewhat resembles fascioliasis. He describes the pathological lesions and states: " The really pathogenic lesions will be seen in the small and large intestine, noticeably so in the pyloric region of the former. Here there will be seen an enteritis, the mucous membranes being necrotic and probably shredding off in places . . . The veins in these areas will have quite a varicose appearance." He further records that he collected amphistomes " in an undeveloped state " from the haemorrhagic area. Specimens were submitted to Looss, at Cairo, who identified them as immature amphistomes. Although Baldrey writes: " In subsequent post-mortems the presence of immature amphistomes was found to be constant and always in the diseases duodenum and pylorus," he did not suspect these parasites as the causal agent because " . . . it is supposed that these organisms have not a very serious effect, ..." This interpretation of Baldrey recalls Cobbold's warning " . . . the student of helminthology must, as a primary discipline, dispose himself of all preconceived opinions whatsoever . . ."

Walker (1906), in a preliminary note discusses this ovine disease " Gillar." According to him, it is practically confined to low-lying swampy areas along the banks of rivers and in parts which are often flooded during the rainy season. The malady is as a rule at its worst during the months of December, January and February. That season would correspond to our winter. He is of the opinion " that the parasite to which it is due passes some period of its existence in marshy places, and that it gains access to the host with the food in September and October, i.e. when the rains and flooded pastures are drying up."

Cotylophoron indicum, Stiles and Goldberger, 1910, has been recorded from *Ovis aries* in India and is according to Maplestone (1923), synonymous with *Cotylophoron cotylophorum*. Fischoeder described the species originally from the stomach (presumably the rumen) of *Bos taurus*, Togo and *Bos zebri*, German East Africa. Maplestone (1923), records it from the stomach of bullocks in Sierra Leone; buffalo and nswala in the Upper Shire River district, Nyasaland; Pagan dwarf bull from Ilorin, Northern Nigeria; waterbuck from Zeref, Khartoum; hartebeest, Nyasaland; antelope sp., Rhodesia and Nyasaland. Ortlepp records it from the rumen of sheep in the Vryheid district, Natal. Mr. D. T. Mitchell, M.R.C.V.S., presented me with specimens from the rumen of a goat slaughtered at the Rangoon Abattoir. Cobbold (1875), records *Amphistomum tuberculatum* from the intestine of Indian cattle. This species may be identical with *C. cotylophorum* whose immature stages have slightly developed cuticular tubercles on the anterior portions of the body. Curson (1928), records *Cotylophoron cotylophorum* as a parasite of the African buffalo in Zululand. At Onderstepoort I have recovered it from both cattle and sheep. From these records it is evident that *C. cotylophorum* has a wide distribution.

The Symptoms Manifested by Infected Sheep.

The symptoms are by no means characteristic for this disease only. The animal appears dull and listless, feeds badly, even when turned on to green oats, and tires readily when driven. The general symptoms of unthriftiness increase rapidly as the disease progresses, the wool becomes dry and harsh, and is easily pulled out. The visible mucous membranes are pale. Oedema of the sub-maxillary subcutaneous tissues develops and as with fascioliasis and other anaemic disorders, it is most pronounced in the evening, while it has practically disappeared by the next morning. A foetid diarrhoea develops early and continues until the animal dies. In a case which showed signs of recovery the autopsy revealed that the parasites had migrated to the rumen.

Post-mortem Appearances.

Seven animals have been destroyed for autopsy. The blood was rather anaemic and stained the fingers poorly. The subcutis contained a fair accumulation of fat showing disseminated fat necrosis. This fat necrosis was general, but was most marked in the intra-abdominal and intra-thoracic collections of fat. In the more chronic cases there was well marked hydro-pericardium, hydro-thorax, hydro-peritoneum, and oedema of the mediastinal, mesenteric and sub-maxillary tissues. Most of the livers showed slight fatty changes. The most pronounced pathological changes were manifested by the first four to eight feet of the duodenum. The blood vessels on the peritoneal surface were engorged and tortuous imparting a cyanosed appearance to the gut. On section the duodenal wall was thickened, the mucosa particularly so. On the congested mucous surface numerous small, flesh coloured objects were present. These were in some cases also recovered from the less congested posterior portion of the gut, as far as the anus. In older standing cases, sand, small pebbles and other foreign bodies half filled the abomasum. In still older cases observed at Onderstepoort some parasites were recovered from the rumen.

The Life-cycle of the Parasite.

Before prophylactic measures can be successfully and scientifically instituted against this disease, it is essential that the time required for the completion of the different stages in the development of the causal parasite be known.

Snails collected from the pool on the farm " Breezy Brae " and, live snails sent by Mr. Hobbs, " Haldon, Petrus Steyn," proved on examination to be infected with an amphistome cercaria, practically identical with *Cercaria frondosa* as described by Faust and claimed by Cawston to be the larval stage of *Paramphistomum calicophorum*, Fischoeder, 1901, which is considered by Maplestone (1923), as identical with *Paramphistomum explanatum* (Creplin, 1847), Fischoeder, 1901.

The developmental stages met with in the livers of dissected snails were sporocysts, rediae, daughter rediae and cercariae. The cercariae when kept in water in a glass dish encysted firmly on the sides of the vessel near the surface of the water or on blades of grass suspended in this water. The encysted cercariae are dark brown in colour and can just be sèen with the naked eye. When they were present in a Petri dish containing a shallow layer of water they encysted at the bottom but were never seen floating about in the encysted stage. They cast their tails before encysting. If the encysted trematode is now ingested, it arrives in the duodenum where it attaches itself, feeds and grows until it migrates to the rumen to mature and oviposit. The contents of the duodenum being rich in semi-digested material is undoubtedly most suitable food for the young paramphistomes. This selection of the duodenum by the young forms and their ultimate migration to the rumen illustrates Cobbold's lines: " None of the internal parasites continue in one stay; all have a tendency to roam; migration is the soul of their prosperity; . . . . To attack, to invade, to infest, is their legitimate prerogative. Their organization, habits and economy are expressly fashioned to this end."

On its migration to the rumen its life as a *true* parasite would appear to cease. There is no evidence that the host is injured to any appreciable degree by its sojourn in the rumen. Van Beneden (1889), discussing " Free messmates " writes: " Worms which have less freedom, like the Distomians, are sometimes both messmates and parasites."

C. cotylophorum is a true parasite while inhabiting the lumen of the duodenum, but would seem to inhabit the rumen for protection. The observations on the migration of the species under discussion confirms Looss' observations that amphistomes first inhabit the small intestine before " they return to the first stomach which is their definite habitat."

The Rate of Development in the Vertebrate and Mollusc Hosts.

From the available data it would seem as if the development of the parasite in the verebrate host is very slow, and that approximately six to eight weeks are spent in the duodenum, while another eight weeks will probably elapse before eggs are passed. At present there is no indication as to the time required for the completion of the cycle in the mollusc. The two outbreaks investigated suggest that the snails become infected in the summer and that encysted cercariae are abundantly present in the vegetation by about May. That some may survive the winter in the snail and emerge early in the summer is likely, but undoubtedly not of common occurrence. It is doubtful whether infected snails would survive the severe winters experienced in those parts.

On the farm "Haldon" the history of the outbreak suggests that infected snails had either survived the winter of 1928 and that the cercariae liberated the following summer infected the sheep in the autumn. The infected camp carried cattle since December, 1928, and it seems probable that these cattle must be held responsible for the infection of the snails which transmitted the parasite to the sheep introduced in May. According to the owner the sheep showed symptoms a fortnight to three weeks after entering this particular field. That the cattle running in the infected camps at "Breezy Brae" did not appear affected, may perhaps be explained by the fact that cattle do not graze as close as sheep. If infection was caused by the water ingested, one would have expected the cattle to have shown symptoms such as diarrhoea.

Treatment.

Tests with carbon tetrachloride proved that this drug had beneficial effects only when administered in doses of from 8 to 10 c.c. in raw linseed oil. The simultaneous administration of magnesium sulphate or calcium lactate should, according to various workers, reduce the toxicity of the drug. Infected animals should receive bonemeal to compensate for the loss of calcium. The giving of lime to reduce any hyperacidity of the abomasum may be advisable and is worthy of a trial. There is plenty of scope here for the biochemist, and those interested in pathological physiology.

Prophylactic Measures.

Sheep and freshwater snails are usually never successfully reared in the same field. Snail-infested vleis should, where practical, be drained or fenced off. Local conditions should be studied before advising the farmer which measures to adopt. Mr. Hobbs suggested draining the vlei and planting willows to aid still further in the reduction of the moisture present.

The destruction of the snails by chemicals such as lime or copper sulphate, may be tried. The latter may give good results where the water is not too muddy or too heavily polluted with organic matter. The use of bonemeal and salt lick should be advocated in all infested areas.

The freshwater snails met with in the Union, are imperfectly known, and I appeal to all veterinarians to study their habits, and to submit live specimens for determination, by animal experimentation, of the cercariae present and likely to infest domestic stock. Live snails packed in moist vegetation travel well by post or by passenger train.

LITERATURE.

BALDREY, F. S. H. (1906). Some Problems in Sheep Diseases. *Jl. Trop. Vet. Sc.*, Vol. 1, pp. 388-397.

CAMERON, T. W. M. (1928). Parasites and Parasitology. *Black's Veterinary Dictionary*, p. 696. A. & C. Black, Ltd., London.

COBBOLD, T. S. (1875). Further remarks on Parasites from the Horse and Elephant, with a Notice of New Amphistomes from the Ox. *The Veterinarian*, Vol. 47, pp. 817-821.

COBBOLD, T. S. (1879). *Parasites; A treatise on the entozoa of Man and Animals*, pp. 331-332. J. & A. Churchill, London.

CURSON, H. H. (1928). Metazoan Parasites from Zululand. *S. Afr. Jl. Nat. Hist.*, Vol. 16, pp. 181-187.

EDMONDS, C. R. (1922). *Diseases of Animals in South Africa*, p. 374. Bailliére, Tindall & Cox, London.

FISCHOEDER, F. (1903). Die Paramphistomiden der Saugethiere. *Zool. Jahrb. Syst.*, Vol. 17, p. 485.

FLEMING, G. (1892). *Neumann's Parasites and Parasitis Diseases of Domesticated Animals*, p. 363. Baillière, Tindall & Cox, London.

KAUPP, B. F. (1918). *Animal Parasites and Parasitic Diseases*, Third Ed., Revised, pp. 168-169. Alexander Eger, Chicago.

LOOSS, A. (1908). What is " Schistosomum mansoni " Sambon 1907? *Ann. Trop. Med. and Hyg.*, Vol. 2, p. 181.

MAPLESTONE, P. A. A Revision of the *Amphistomata* of Mammals. *Ann. Trop. Med. and Parasit.*, Vol. 17, pp. 113-212.

NÖLLER, W., AND SCHMID, F. (1928). Zur Kenntnis der Entwicklung von *Paraphistomum cervi* (Schrank) s. Amphistomum conicum (Zeder). *Sitzungsber. d. Ges. Nat. Freunde*, Berlin, No. 8-10, p. 148-154.

PILLERS, A. W. N. (1915). Parasites and Parasitic Diseases. *A System of Veterinary Medicine by various authors.* Edited by E. Wallis Hoare, Vol. 2, p. 1508. Bailliére, Tindall & Cox, London.

SIMSON, W. A. (1926). Amphistome Larvae in Intestines of Cattle and Sheep. *Vet. Rec.*, Vol. 6, No. 34, p. 748.

STILES, C. W., AND GOLDBERGER, J. (1910). A Study of the Anatomy of Watsonius (n.g.) Watsoni of Man and of nineteen allied species of Mammalian Trematode worms of the superfamily Paramphistomoidea. *Hygienic Laboratory, Bull. No.* 60, U.S.A.

TROLLIP, A. (1878). Ordinary sheep fluke and conical fluke in an ox. *Agric. Jl. Cape of Good Hope*, Vol. 6, pp. 424-425.

UNDERHILL, B. M. (1920) *Parasites and Parasitosis of the Domestic Animals*, 167. The Macmillan Company, New York.

VAN BENEDEN, P. J. (1889). *Animal Parasites and Messmates*, Fourth Ed., Kegan Paul, Trench & Co., London.

WALKER, G. K. (1906). A preliminary note on " Gillar," a disease affecting sheep and goats. *Jl. Trop. Vet. Sc.*, Vol. 1, pp. 410-413.

WOOLDRIDGE, G. H. (1923). *Encyclopaedia of Veterinary Medicine, Surgery and Obstetrics*, Vol. 1, p. 315. Henry Frowde and Hodder and Stoughton, London.

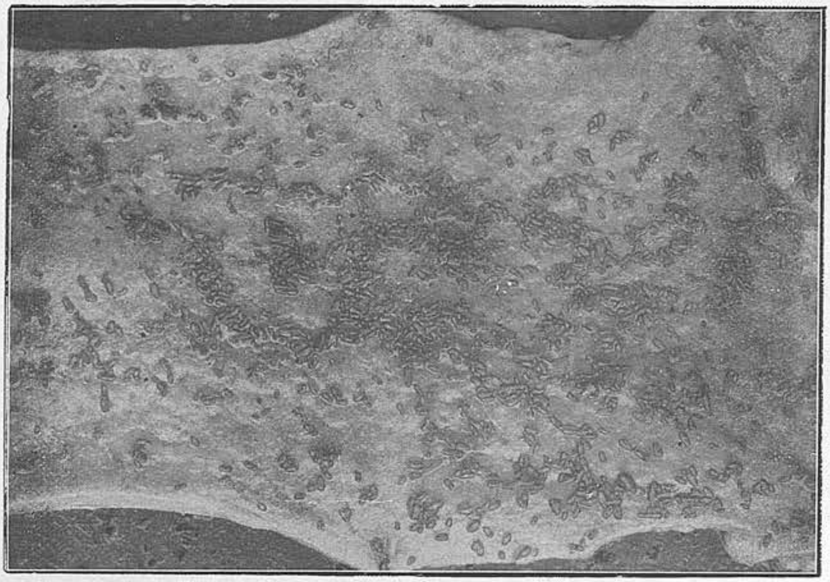


FIG. 1.

Fig 1. Photograph of a portion of the duodenum showing mass infestation with immature paramphistomes. Natural case from "Breezy Brae."

FIG. 2.

Fig. 2. Photograph of a portion of the duodenum showing verrucose appearance of the mucosa and whitish raised areas (sites of attachment). Another natural case from "Breezy Brae."

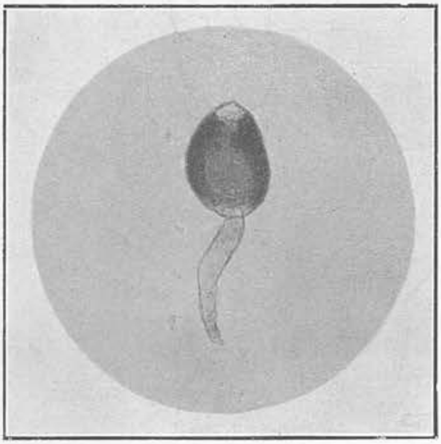


FIG. 3.

Fig. 3. Microphotograph of a cercaria showing " eye "-spots. Specimen from the liver of *Bulinus* sp. off " Haldon."

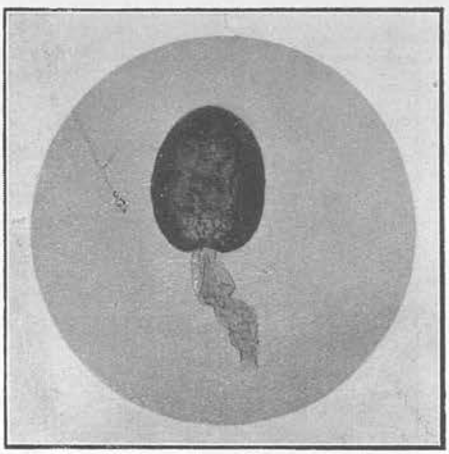


FIG. 4.

Fig. 4. Microphotograph of a cercaria after escape from a snail off " Haldon." Note pigment distributed throughout the body.

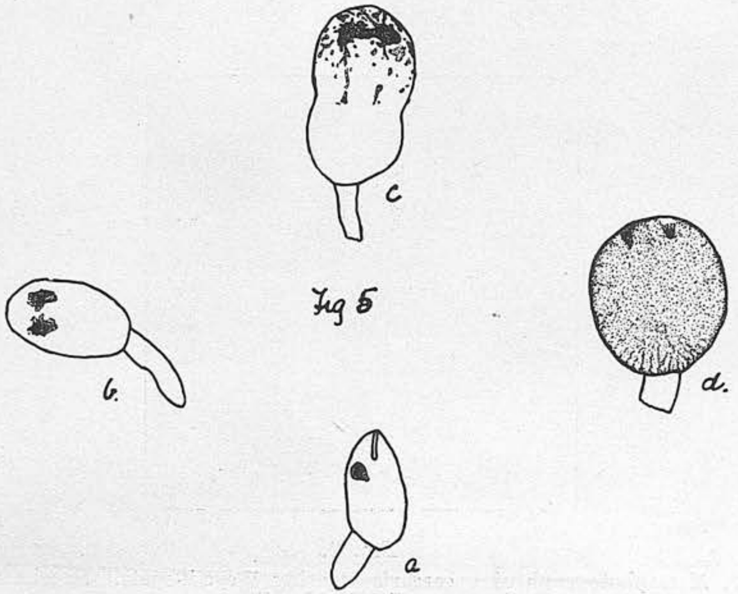


Fig. 5. Cercariae from a snail off "Haldon."

a. Lateral view of an immature cercaria showing one "eye"-spot.
b. Dorsal view of an immature cercaria showing the two "eye"-spots.
c. A dorsal view of a more matured cercaria showing radiation of the pigment from the "eye"-spots.
d. Ventral view of an almost matured cercaria showing the "eye"-spots and the pigment disseminated throughout the body.

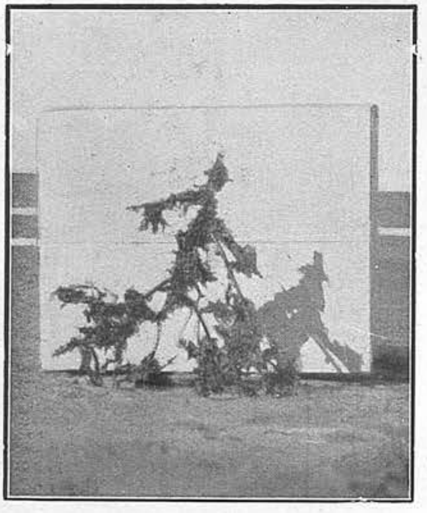


FIG. 6.

Fig. 6. Photograph of a plant with *Bulinus* sp. adhering. Plant removed from the snail infested pool at "Breezy Brae."

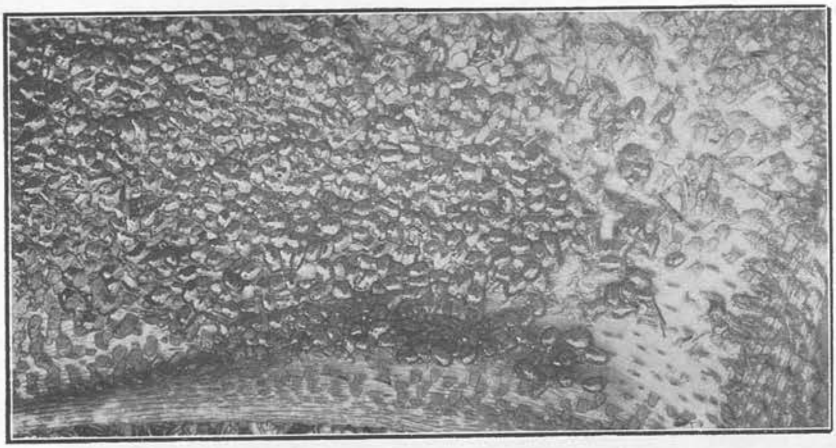


FIG. 7.

Fig. 7. Portion of Rumen showing *Cotylophoron cotylophorum* adhering.

Article No.13.

Journal of Helminthology, *Vol.* IX, *No.* 3, *July*, 1931, *pp.* 141-146.

On *Longistrongylus meyeri* gen. and sp. nov., a Trichostrongyle parasitizing the Red Hartebeest *Bubalis caama*.

By P. L. LE ROUX, B.Sc., M.R.C.V.S.
(*Lately Veterinary Research Officer, Onderstepoort, Pretoria.*)

INTRODUCTION.

IN June, 1930, the writer received from Mr. T. Meyer of Onderstepoort, some parasites collected from a red hartebeest at Gobabis in South West Africa. The examination of this material revealed the presence of rather long slender worms which could not be allocated to any of the known genera of the sub-family *Trichostrongylinæ*, Leiper, 1908. The genus *Longistrongylus* is proposed for the reception of this species which is named *Longistrongylus meyeri* gen. and sp. nov., in honour of the collector and donor.

LONGISTRONGYLUS GEN. NOV.

Definition. *Trichostrongylinæ* : Head relatively large, lips inconspicuous, buccal cavity small ; cervical papillæ present, but small ; cuticle with very fine closely spaced transverse striations, prominent longitudinal ridges intersecting the transverse striations. *Male* : Copulatory bursa with large lateral lobes and a distinct, but much smaller symmetrical dorsal lobe with the following formula : Ventro-ventral and latero-ventral, arising from a short common trunk proximally, are long, parallel, equal in size and terminate close to the edge of the bursa ; externo-lateral stops short of the edge of the bursa and its distal extremity is well separated from the neighbouring rays ; medio-lateral and postero-lateral, about equal in dimensions, are long, parallel and arising from a short common trunk proximally end near the edge of the bursa ; externo-dorsal springs from the base of the dorsal ray and is short ; dorsal ray bifurcates almost immediately into two short stout branches, each of which in turn terminates in two or three very short digits ; prebursal papillæ long and stout ; spicules equal, slender, alate and each ending in two short points ; telamon present. *Female*: Uteri divergent and opposed ; vulva in the posterior fifth of the body and opening into a transverse depression ; tail rather bluntly pointed ; oviparous.

Type species : *Longistrongylus meyeri* sp. nov.

	Females.			Males.	
Length of body	24·5	25·2	27·3	14·4	15·8
Diameter of head	0·062	0·063	0·065	0·036	0·037
Maximum breadth of body ...	0·384	0·437	0·375	0·247	0·263
Breadth of body at base of œsophagus	0·214	0·212	0·207	0·247	0·240
Anterior extremity to nerve ring ...	0·436	0·425	0·463	0·336	0·357
Anterior extremity to excretory pore	0·684	0·653	0·764	0·454	0·516
Anterior extremity to cervical papillæ	0·735	0·674	0·727	0·486	0·547
Anterior extremity to vulva ...	19·374	21·362	21·473	—	—
Length of œsophagus	1·362	1·652	1·463	1·218	1·212
Maximum width of œsophagus ...	0·144	0·126	0·138	0·097	0·095
Minimum width of œsophagus ...	0·036	0·047	0·043	0·027	0·032
Anus to posterior extremity ...	0·245	0·243	0·252	—	—
Length of rectum	0·133	0·133	0·133	—	—
Measurements of the eggs *in utero* { Length	0·075	0·077	0·077	—	—
Breadth	0·045	0·045	0·048	—	—
Length of spicules	—	—	—	0·300	0·312
Dorsal lobe of copulatory bursa { Length	—	—	—	0·048	0·053
Breadth	—	—	—	0·108	0·113
Lateral lobes of copulatory bursa { Length	—	—	—	0·288	0·315
Breadth	—	—	—	0·300	0·327

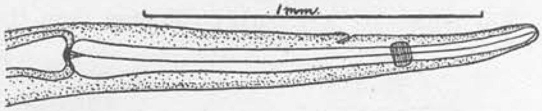
MORPHOLOGY OF *Longistrongylus meyeri*.

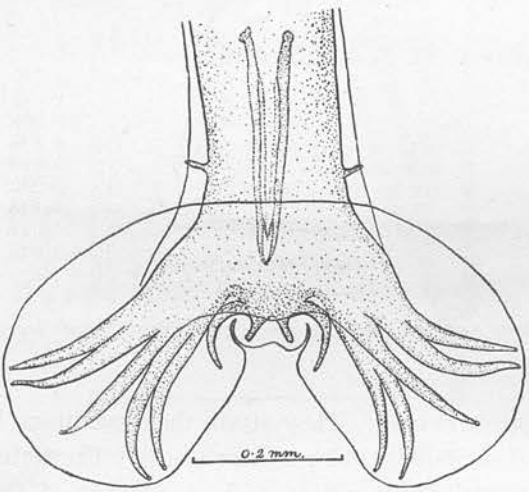
The different measurements of the three females and the two males are shewn in the subjoined table.

The worms are rather long and thin. They are fairly straight, although primarily preserved in 10 per cent. formalin and are dark red in colour. Live specimens were, according to the donor, deep dark red in colour at the time of collection. That the species is an active blood sucker would seem possible judging from the dark amorphous pigment present in the intestinal cells throughout the whole length of the intestine.

Anteriorly and posteriorly the female is attentuated. The attenuation is more gradual anteriorly.

The cephalic extremity bears ill-defined lips with the usual circum-oral papillæ inconspicuous. The oral aperture leads into a very small buccal cavity, followed by the type of œsophagus typical of the sub-family (fig. 1). The œsophageo-intestinal valves are not well developed. The rectum is of the usual type and the anus, in the female, oval in outline.





Longistrongylus meyeri n.g., n.sp.

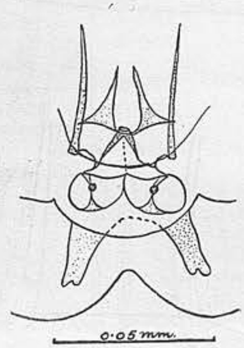
Fig. 1.—Cephalic extremity.

Fig. 2.—Bursa spread out. Spicules showing.

The cervical papillæ are rather small nipple-like projections situated on a level slightly posterior to the excretory pore which in turn is posterior to the nerve ring.

The cuticle bears from forty to about fifty well-developed longitudinal lines towards the posterior part of the body. These lines extend from about the level of the nerve ring to the level of the anus in the case of the female and the prebursal papillæ in the male. They are more numerous posteriorly than anteriorly, and do not in every case extend uninterruptedly from in front to behind. The transverse striations are ill-defined and very closely spaced together. They are interrupted by the well-developed longitudinal ones.

The male. The males are less darkly coloured than the females and



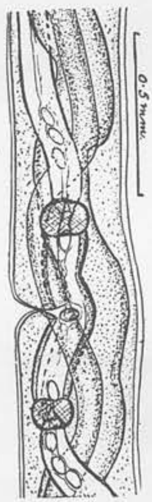
Longistrongylus meyeri.

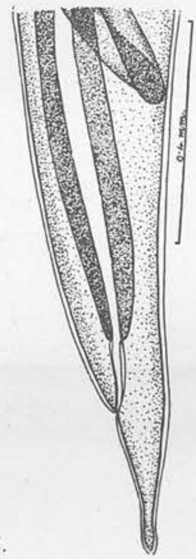
Fig. 3.—Telamon as far as could be made out. Branches of dorsal ray showing.

appear much more slender. They attain their maximum breadth about the junction of the middle and posterior thirds. The testis is prominent and extends anteriorly to within a short distance of the base of the œsophagus. The spicules are similar in shape and size, but rather small and slender. Each spicule bears a spur ventrally towards its distal extremity which ends in a sharp slightly curved point. The spur is the termination of the transversely striated ala with which each spicule is furnished (fig. 2). The copulatory bursa is comparatively under-developed for a worm of this size. The lateral lobes are supported by rays as figured (fig. 2).

The spicules are guided by a telamon. The exact build of this structure could not be accurately ascertained (fig. 3). The cloacal aperture is furnished ventro-laterally with two papillæ around which the cuticle is inflated to form spherical swellings (the genital cone). These two papillæ have been observed in *Hæmonchus contortus, Trichostrongylus axei, T. instabilis, T. rugatus* and *T. falculatus.*

The Female. Microscopically these parasites may, on account of the twisting of the genitalia around the reddish coloured intestine, be mistaken for specimens of *Hæmonchus* Cobb, 1898 ; *Ashworthius* le Roux, 1930 ; or even other members of this large sub-family.





Longistrongylus meyeri.

Fig. 4.—Body of female in region of vulva.
Fig. 5.—Caudal extremity of female.

The vulva is situated in a transverse depression on the ventral aspect of the parasite. The vagina is very short. The ovejectors (fig. 4) are muscular. The eggs *in utero* measure from 75μ to 77μ in length and attain a breadth of from 45μ to 48μ, and show segmentation. This segmentation may, however, have taken place after the collection and the preservation in formalin. The caudal extremity is attenuated and ends in a rather blunt point. The caudal papillæ are present.

Co-types of this species will be deposited in the Helminthological collection at Onderstepoort and in the collection of the Imperial Bureau of Agricultural Parasitology, St. Albans, as well as with the Department of Zoology, University of Edinburgh.

Article No.14.

From the Annals and Magazine of Natural History,
Ser. 10, vol. x. p. 502, *November* 1932.

On Trichostrongylus pietersei, *sp. n., a Parasite of Sheep and Goats.* By P. L. Leroux, B.Sc., M.R.C.V.S., Central Research Station, Mazabuka, Northern Rhodesia.

Introduction.

The examination of the helminths collected from the gastro-intestinal tract of two Black-head Persian ewes which had died at the above institute shortly after their importation from Norval's Pont, Cape Province, revealed the presence of a new species of *Trichostrongylus* Looss, 1905. This species was found along with numerous specimens of *Trichostronglus falculatus* Ransom, 1912, and a few specimens of *Trichostrongylus instabilis* Looss, 1905.

The recovery of this new species induced me to examine the helminths collected a few years ago from sheep from Graff-Reinet and from Angora goats from Willowmore in the Cape Province. The examination of this hitherto unidentified material proved that the new species and *T. falculatus* were present in every animal (six merino sheep and three Angora goats). A further examination of material collected from sheep in various parts of South Africa proved that the new species and *T. falculatus* were present only in sheep and goats on the arid central plateau, known as the Karroo, or in animals originally imported from that area not many months prior to the collection o the material.

For this new species the name *Trichostrongylus pietersei*, sp. n., is designated in honour of Mr. W. Pieterse, Department of Helminthology, Onderstepoort, in recognition of his services to helminthology in South Africa.

Since this species was invariably met with in association with either one or more of the common trichostrongyles parasitizing the sheep and goat in Southern Africa, a description of the female is not available.

Characters of the Male.

The males possess all the diagnostic characters defined for the genus *Trichostrongylus* Looss, 1905.

The males are 5·2 mm. to 6·8 mm. long, and the maximum width of their bodies varied from 85 μ to 90 μ in the region of the spicules. The œsophagus has a length of 850 μ to 858 μ with a maximum diameter of about 27 μ posteriorly. The excretory pore opens into what may be termed a cervical groove, situated at a distance of about 1·42 mm. from the cephalic extremity. This groove, which is formed by a circular constriction of the body, is most prónounced ventrally. The diameter of the head is 12 μ. In front of the cervical groove the body has a dorso-ventral diameter of 28 μ, which is reduced to 22 μ by the constriction, and immediately increases again to 25 μ. From here onwards the body gradually increases in diameter to attain its maximum width on a level with the spicules just in front of the bursa. Minute prebursal papillæ are present. The copulatory bursa has its rays arranged as figured (fig. 1). The two spicules (fig. 2), which are highly chitinized, vary slightly in their lengths, measuring 137 μ and 129 μ in the left and right respectively. The build of these spicules proves that the species is closely related to *Trichostrongylus falculatus* Ransom, 1912, *Trichostrongylus probolurus* (Railliet, 1896) Looss, 1905, and *Trichostrongylus instabilis* Looss, 1905. It is most closely related to *T. probolurus*, from which it differs in that the distal extremity of each spicule is much more slenderly built and markedly attenuated dorso-ventrally. The distal hook on the spicule is prominent and is situated at a distance of 28 μ from the caudal extremity. The second hook is still more conspicuous and is localized at a distance of 28 μ in front of the distal one. In *T. probolurus* the corresponding measurements, judging from the drawings of the spicules in Ransom (1910), would appear to be

$36\,\mu$ and $28\,\mu$. In *T. instabilis* the anterior hook is absent, while the two are close together in *T. falculatus*. The gubernaculum measures about $98\,\mu$ and is of the usual type.

The type-specimens, together with the co-types, will be deposited in the helminthological collection of the Imperial Bureau of Agricultural Parasitology, St. Albans, England.

Fig. 1.

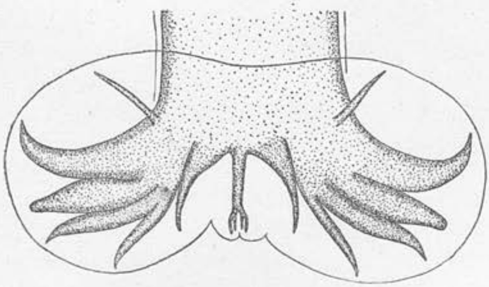


Fig. 2.

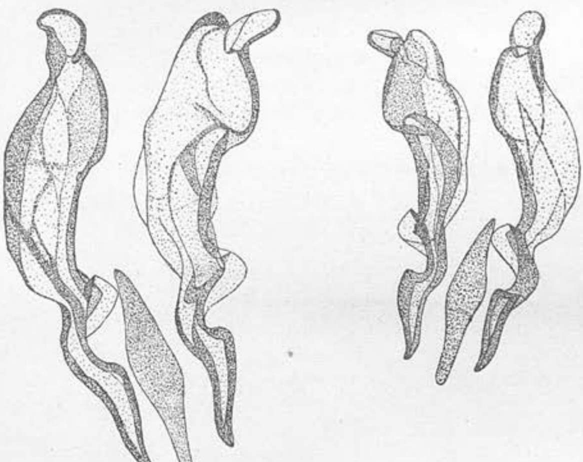


Fig. 1.—Ventral view of bursa.
Fig. 2.—Spicules and gubernaculum viewed from different angles.

References.

Ransom, B. H. 1910. "The Nematodes parasitic in the Alimentary Tract of Cattle, Sheep, and other Ruminants." U.S. Dept. Agric., Bur. Anim. Ind. Bull. no. 127.

——. 1911. "Two new Species of Parasitic Nematodes," no. 1864, Oct. 31, 1911. Proc. U.S. Nat. Mus. vol. lxi. (1912).

Article No. 15.

Journal of Helminthology, Vol. XI, *No.* 1, *January*, 1933, *pp.* 57-62.

A Preliminary Note on *Bilharzia margrebowiei*, a new Parasite of Ruminants and possibly of Man in Northern Rhodesia.

By P. L. LEROUX, B.Sc., M.R.C.V.S.
(Central Research Station, Mazabuka, N. Rhodesia.)

INTRODUCTION.

DURING the examination of numerous specimens of Bilharzia collected from domesticated and wild ruminants in this Territory a species of bloodfluke, closely related to the vector of intestinal bilharziasis in the Far East, was observed. For this species the name *Bilharzia margrebowiei* sp. nov. is designated in honour of my wife, Dr. Margaret Gregor Leroux (née Bowie), for the self sacrificing way in which she has assisted me in the past.

The study of the literature, dealing with bilharziasis in Africa, suggests that the eggs of this species have possibly been met with in human stools in Central Africa.

The specimens, on which the diagnosis of this species is based, were collected from cattle, a zebra, lechwe kobs (*Cobus leche* Gray), reedbuck (*Redunca arundinum* Bodd.), pukus (*Cobus vardoni* Livingstone) a blue wildebeest or brindled gnu (*Connochaetes taurinus* Burch.), a situtunga or water kudu (*Tragelaphus spekei selousi* Roth.), and a roan antelope (*Hippotragus equinus* Desm.).

Bilharzia margrebowiei was invariably found along with other species of Bilharzia in the various hosts mentioned above. In the majority of hosts it was found to inhabit the radicles of the portal vein along with *Bilharzia spindalis*. In a few cases the hosts were also infested with *Bilharzia mattheei* (Veglia and Le Roux, 1929).

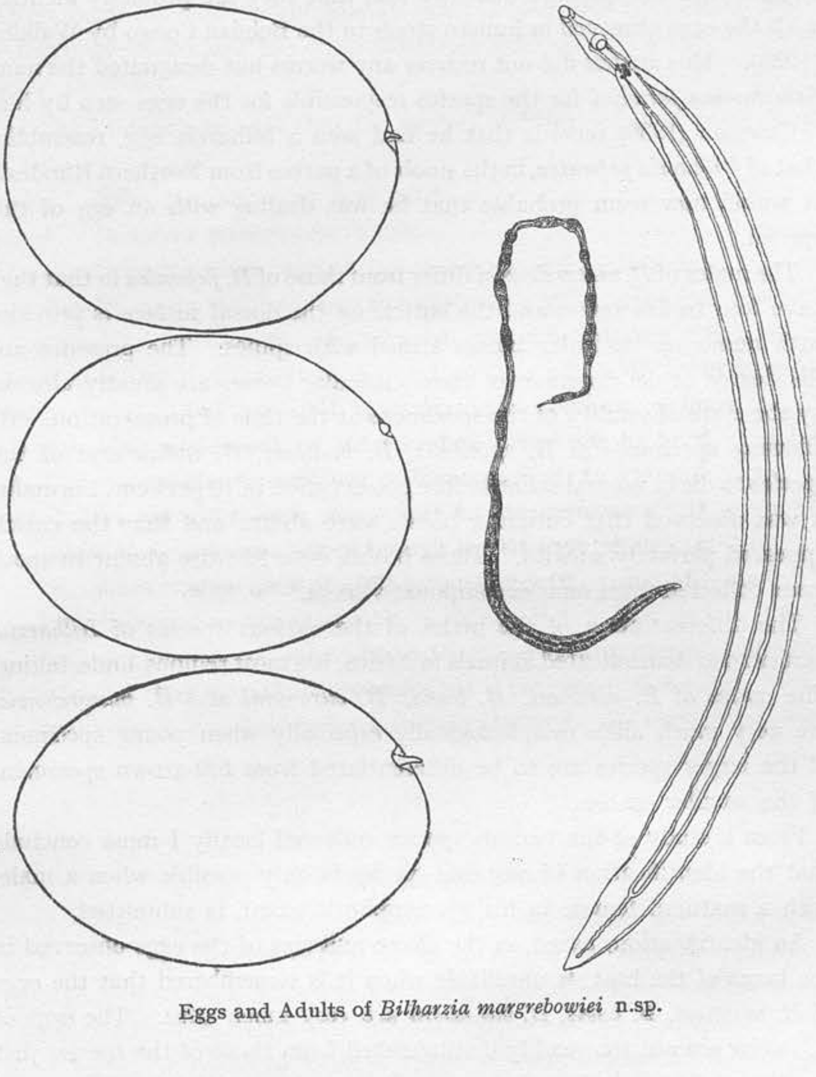
Bilharzia spindalis (Montgomery, 1906) and *Bilharzia mattheei* are common parasites of sheep, cattle and antelopes in this locality. The latter has been collected from man and the baboon *Papio porcarius* in Southern Rhodesia by Blackie (1932).

MORPHOLOGY OF *Bilharzia margrebowiei* SP. NOV.

Male.—12 to 18 mm. long by 0·857 mm. to 1·254 mm. wide. Cuticle armed with bosses and spines dorsally and spines ventrally. Inner surfaces of suckers provided with spines. Oral sucker subterminal, with a lateral diameter of 200μ to 240μ. Ventral sucker pedunculated and situated at a variable distance, according to the state of contraction of the individual, from the oral sucker. Testes, usually four more rarely five in number, measure approximately 176μ by 160μ. The seminal vesicle in front of the testes and variable in dimensions depending on the sexual activity of the individual at the time of collection. In some specimens the measurements of this organ were 176μ by 112μ. The intestinal cæca unite very late as figured in the accompanying drawing.

Female.—14 mm. to 20 mm. long by 270μ to 320μ wide. Inner surfaces of both suckers and posterior portion of body armed with spines. Ovary, somewhat pear-shaped, 688μ long by 225μ wide and situated at equator in well preserved specimens. In specimens collected from slightly decomposed viscera the ovary was post-equatorial (See Fig., p. 59.) Uterus long and containing numerous eggs arranged in clumps as figured. Eggs (See Fig.), practically oval, 60μ by 45μ to 70μ by 42μ, provided with a small subterminal knob, rudimentary or well developed spine as figured. Vitellaria occupy the posterior half of the worm in freshly collected and well preserved specimens. These organs are, in specimens collected from semi-decomposed viscera, confined to less than the posterior half, owing to the undue elongation of the ante-ovarial half of the worms.

It cannot be over-emphasized that the various measurements of all trematodes but more especially the members of the genus *Bilharzia*, are subject to enormous variations brought about by methods of collection, modes of preservation and the state of putrefaction of the viscera of the host at the time of collection.



Eggs and Adults of *Bilharzia margrebowiei* n.sp.

Discussion.

The species described above is larger than any of the other locally collected members of the genus. A casual examination of a female would suggest that the eggs are unarmed and that they are probably identical with the eggs observed in human stools in the Belgian Congo by Walkiers (1928). This author did not recover any worms but designated the name *Schistosoma faradjei* for the species responsible for the eggs seen by him.

Cawston (1930) records that he had seen a bilharzia egg, resembling that of *Bilharzia japonica*, in the stools of a native from Northern Rhodesia. It would now seem probable that he was dealing with an egg of this species.

The males of *B. margrebowiei* differ from those of *B. japonica* in that they have four to five testes and the cuticle on the dorsal surface is provided with numerous cuticular bosses armed with spines. The presence and the degree of development of these cuticular bosses are greatly affected by the state of vitality of the specimens at the time of preservation. By allowing specimens of *B. spindalis*, *B. mattheei*, *B. indica* and of this species to die in normal saline before preservation in 10 per cent. Formalin, it was observed that cuticular bosses were absent and that the cuticle appeared perfectly smooth. These bosses were likewise absent in specimens collected from semi-decomposed viscera.

The differentiation of the males of the various species of *Bilharzia*, parasitizing domesticated animals in Africa, is a most tedious undertaking. The males of *B. mattheei*, *B. bovis*, *B. curassoni* and *B. margrebowiei* are very much alike morphologically especially when young specimens of the larger species are to be differentiated from full-grown specimens of the smaller species.

From a study of the various species collected locally I must conclude that the identification of any one species is only possible when a male, with a matured female in his gynæcophoric canal, is submitted.

An identification, based on the shape and size of the eggs observed in the fæces of the host, is unreliable when it is remembered that the eggs of *B. mattheei*, *B. bovis*, *B. curassoni* are very much alike. The eggs of *B. indica* are not too readily distinguished from those of the species just mentioned. It is in human cases quite possible to mistake the eggs of *B. mattheei* for those of *B. hæmatobia* and those of *B. margrebowiei* for those of *B. japonica*.

It may be mentioned here that I have obtained from a zebra and wild ruminants a species which has tentatively been identified as *Bilharzia indica* (Montgomery, 1906) and it would now seem probable that either this species or *Bilharzia curassoni* (Brumpt, 1931), or both, may in Central Africa be responsible for the human cases of intestinal bilharziasis where a terminal-spined egg has been observed without the urinary bladder being involved.

It is of interest to note that the species of Bilharzia now known from Africa are :—

1. *Bilharzia hæmatobia* from man.
2. *Bilharzia mansoni* from man.
3. *Bilharzia bovis* from sheep, cattle and man (?).
4. *Bilharzia mattheei* from sheep, goats, cattle, antelopes, baboons, man and the grey monkey (experimental infection).
5. *Bilharzia spindalis* from sheep, cattle, horse, antelopes and man (Porter, 1929).
6. *Bilharzia spindalis* var. *africana* from man.
7. *Bilharzia curassoni* from cattle.
8. *Bilharzia lombarti* (Syn. *Schistosoma rodhaini* Brumpt, 1931) from an experimentally infected mouse.
9. *Bilharzia indica* from zebra and antelopes.
10. *Bilharzia margrebowiei* from cattle, etc.

The type specimens and co-types of *Bilharzia margrebowiei* sp. nov. have been deposited in the Helminthological Collection of the Department of Helminthology at the London School of Hygiene and Tropical Medicine.

Acknowledgements.

The writer takes this opportunity of acknowledging his indebtedness to Prof. J. H. Ashworth and Prof. R. T. Leiper for working facilities in their respective departments in Edinburgh and in London, and for having had access to their collections of helminthological material which proved most helpful in the identification of the helminths collected in Northern Rhodesia. He further wishes to express his gratitude to Prof. E. Brumpt for specimens of *Bilharzia bovis*.

REFERENCES.

BLACKIE, W. K., 1932.—" A helminthological survey of Southern Rhodesia." *Mem. London School Hyg. Trop. Med.*, No. 5, London.

BRUMPT, E., 1931.—" Description de deux bilharzies de mammiferes africains, *Schistosoma curassoni* sp. inquir. et. *S. lombarti* n. sp." *Ann. Par. Hum. Comp.*, Vol. ix, No. 1, pp. 325-338.

CAWSTON, F. G., 1930.—" Schistome resembling *S. japonicum* in South Africa." *J. Trop. Med.*, Vol. xxxiii, No. 19, p. 292. (*W.L.* 11587.)

PORTER, ANNIE, 1926.—" Notes on the structure and life history of a variety of *Schistosoma spindalis* Montgomery observed in South Africa." *S. Afr. J. Sci.*, Vol. 23, pp. 661-666. (*W.L.* 20357.)

— 1929.—" Some South African Larval fluke." *Journal of Scientific Transactions, Brit. Assoc. Advancement of Science*, South Africa, 1929, pp. 24-25.

PRICE, E. W., 1929.—" A synopsis of the trematode family Schistosomidæ with description of new genera and species." *Proc. U.S. Nat. Mus.*, Vol. lxxv, Art. 18, pp. 1-39. (*W.L.* 16944.)

VEGLIA, F. and LE ROUX, P. L., 1929.—"On the morphology of a schistosome (*Schistosoma mattheei* sp. nov.), from the sheep in the Cape Province. *15th Rep. Dir. Vet. Services*, pp. 335-339.

Article No. 16.

From the Annals and Magazine of Natural History, Ser. 10, vol. xi. p. 222, *February* 1933.

On Tenuostrongylus cynictis, *gen. et sp. n., a Trichostrongylid parasitizing the Yellow Mungoose* (Cynictis penicullata). By P. L. Leroux, B.Sc., M.R.C.V.S., Central Research Station, Mazabuka, Northern Rhodesia.

The specimens described in this communication were collected by the writer from a yellow mungoose, shot in the Bloemhof area, western Transvaal.

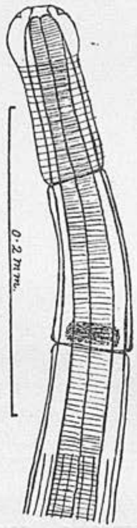
Although this species has certain characters in common with the species of Trichostrongylidæ recovered from carnivores from South America, West Africa, and the Malay States, it could not be referred to any one of the genera *Molineus* Cameron (1923), *Microstrongylus* Cameron

(1927), and *Nematostrongylus* Cameron (1928), and the name *Tenuostrongylus cynictis*, gen. et sp. n., is designated for it.

Characters common to both Sexes.

The freshly collected specimens were flesh-coloured. This colour turned a dirty brown on their preservation in boiling glycerine-alcohol. The worms are comparatively long but slender, and have the cuticle on the cephalic extremity markedly inflated (fig. 1). This

Fig. 1.



Cephalic extremity.

inflation, which has a maximum diameter of approximately 50 μ in its anterior third, extends posteriorly for a distance of 98 μ and 108 μ in the males and females, respectively. Posteriorly the inflation is demarcated from the rest of the body by a groove formed by the non-inflation of the cuticle followed again by a very slightly inflated cuticle. This non-inflation of the cuticle surrounds the body completely and is identical with the cervical ring described by Cameron (1923, 1927, and 1928) for certain trichostrongylids from carnivores. The transverse striations are prominent on the inflated portion of the cuticle, but do not encircle the body completely, as they terminate at the lateral lines.

The excretory pore opens into a groove which corresponds with the cervical groove described by Cameron (1927) for *Microstrongylus genettæ*. The cervical groove encircles the body completely and is situated at a distance of 188 μ and 217 μ from the cephalic extremity in the male and female, respectively. Anteriorly and posteriorly to this groove the cuticle is somewhat thickened.

The nerve-ring is situated just in front of the cervical groove and very minute cervical papillæ were observed immediately posterior to the groove. Cervical papillæ are also present in *Molineus felineus*, *Microstrongylus genettæ*, and *Nematostrongylus planicipitis*, and are situated just posterior to the level on which the excretory pore opens. They could only be detected under high magnification and in properly orientated specimens. It is doubtful whether these structures are absent in any species of Trichostrongylidæ.

At a distance of approximately 70 μ posterior to the cervical groove there appear longitudinal circular striations which extend posteriorly to the prebursal region in the male and to the anal region in the female. These striations are approximately 8 μ apart. On the more posterior parts of the body they number about sixteen, while half that number was met with in the more anterior regions. Under very high magnification their free edges appear beaded owing to the transverse striations crossing them.

The anterior extremity, which is attenuated, bears the oral aperture centrally placed and surrounded by the usual six circumoral papillæ met with in nematodes. These circumoral papillæ are rather minute, but their presence is readily proved by the indentations of the inflated cuticle. The buccal cavity is ill-developed and leads into an œsophagus which attains a length of 450 μ and 465 μ in the male and female respectively, while its maximum diameters in the corresponding specimens are 33 μ and 42 μ.

Male Characters.

The male is 5·5 mm. long, and its body attains a maximum diameter of 81 μ in front of the copulatory bursa, which has its lateral wings folding in and overlapping ventrally. When opened out it is 144 μ long and 240 μ wide. Its ventral surface has the central portion studded with minute structures resembling spines. The distribution of the bursal rays is as figured (figs. 2 & 3).

Fig. 2.

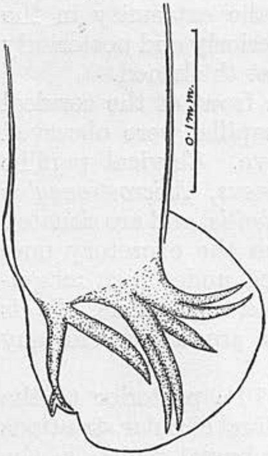


Fig. 3.

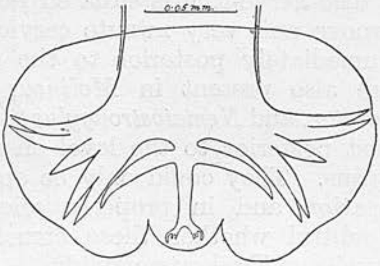


Fig. 2.—Lateral view of bursa.
Fig. 3.—Bursa spread open.

Prebursal papillæ are very minute and were only detected under high magnification and in properly orientated specimens.

Fig. 4.

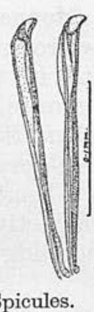


Fig. 5.

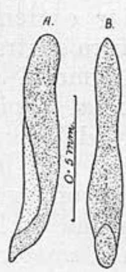


Fig. 4.—Spicules.
Fig. 5.—Gubernaculum: A, lateral view; B, ventral view.

The spicules (fig. 4), which are similar in build and length (184 μ), are well chitinised. The main body of each spicule terminates distally in a globular swelling, while the spur, measuring approximately 90 μ in length, ends as an attenuated process.

The gubernaculum (fig. 5, A & B) is a relatively well-chitinised boat-shaped-like structure having a length of 90 μ.

Fig. 6.

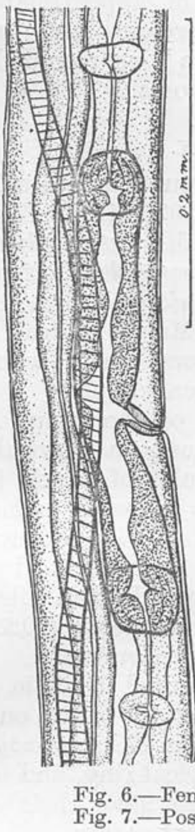


Fig. 7.

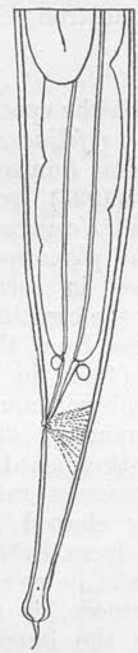


Fig. 6.—Female in region of vulva.
Fig. 7.—Posterior end of female.

Female Characters.

The female is 8·5 mm. long with a maximum diameter of 113 μ in the region of the vulva.

The vulva is situated at a distance of 1·34 mm. anterior to the anus and leads anteriorly into a short vagina which communicates with the ovejectors measuring

30 μ in length and having an average diameter of 45 μ. The anterior ovejector is very slightly shorter than the posterior one. Twelve eggs were observed in the anterior uterus, while the posterior one held ten. The measurements of these eggs varied from 50 $\mu \times 40$ μ to 60 $\mu \times 35$ μ.

The anus is situated at a point 1·35 mm. in front of the posterior extremity, which has its cuticle slightly swollen, giving it a diameter of approximately 16 μ. The usual caudal papillæ are present, and the tail is furnished with a slender "spike" as recorded for the other Trichostrongylidæ of carnivores.

Discussion.

Although the species under discussion is closely related to *Molineus felineus* Cameron (1923) from *Felis yaguarundi* from South America, *Microstrongylus genettæ* Cameron (1927) from *Genetta senegalensis* from West Africa, and *Nematostrongylus planicipitis* Cameron (1928) from *Felis planiceps* from the Malay States, it differs from them in certain characters which would seem to justify the creation of a new genus.

It differs from the members of the genus *Molineus* Cameron (1923) in that it possesses a cervical groove, a stout gubernaculum, and spicules of which the main body terminates distally in a globular point. It is readily distinguished from *Microstrongylus* Cameron (1927), which possesses rather slender spicules and a much differently shaped gubernaculum. It can likewise be separated from *Nematostrongylus* Cameron (1928) on the characters of its spicules and gubernaculum.

Furthermore, it may be observed that in *Nematostrongylus* the longitudinal striations start on a level with the excretory pore, while in *Microstrongylus* they originate on a level with the cervical ring, and in *Tenuostrongylus* they were observed to have their origin at a level well posterior to the cervical groove.

Whether the characters which differentiate the different genera are of real generic significance remains to be proved or disproved as more trichostrongylids are recovered from carnivores. At present the recognition of the different genera seems well founded.

The type-specimens of *Tenuostrongylus cynictis*, gen. et sp. n., will be deposited in the Helminthological collection of the Imperial Bureau of Agricultural Parasitology, Winches Farm, St. Albans, England.

ACKNOWLEDGMENTS.

The writer feels greatly indebted to Prof. R. T. Leiper and Dr. T. W. M. Cameron for lending for examination the cotypes of the species described by the latter. To Prof. J. H. Ashworth I am indebted for laboratory facilities enjoyed in the Department of Zoology, University of Edinburgh, during my visit to Edinburgh this year.

REFERENCES.

CAMERON, T. W. M. 1923. "Studies on Two new Genera and some little-known Species of the Nematode Family Trichostrongylidæ Leiper." Journ. Helm. vol. i. pp. 71–96.

——. 1927. "On *Microstrongylus genettæ*, gen. et sp. n., a Trichostrongyle Parasite of *Genetta senegalensis*." Journ. Helmin. vol. v. pp. 81–88.

——. 1928. "On some Parasites of the Rusty Tiger-Cat (*Felis planiceps*)." Journ. Helm. vol. vi. pp. 87–98.